US007134956B2

(12) **United States Patent**
Lee

(10) **Patent No.: US 7,134,956 B2**
(45) **Date of Patent: Nov. 14, 2006**

(54) **AUTOMATED FEET-GRIPPING SYSTEM**

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(73) Assignee: **Georgia Tech Research Corporation**, Atlanta, GA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/618,523**

(22) Filed: **Jul. 11, 2003**

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US 2004/0067725 A1 Apr. 8, 2004

Related U.S. Application Data

(63) Continuation-in-part of application No. 09/748,656, filed on Dec. 22, 2000, now Pat. No. 6,623,346.

(60) Provisional application No. 60/171,990, filed on Dec. 23, 1999, provisional application No. 60/177,576, filed on Jan. 22, 2000, provisional application No. 60/197,362, filed on Apr. 15, 2000, provisional application No. 60/252,987, filed on Nov. 23, 2000.

(51) **Int. Cl.**
A22B 1/00 (2006.01)

(52) **U.S. Cl.** **452/53**; 452/179

(58) **Field of Classification Search** 452/52, 452/53, 54, 55, 56, 163, 166, 167, 177, 178, 452/179, 180, 181, 183, 184, 187, 188, 194
See application file for complete search history.

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Primary Examiner—Jeffrey L. Gellner
Assistant Examiner—David J. Parsley
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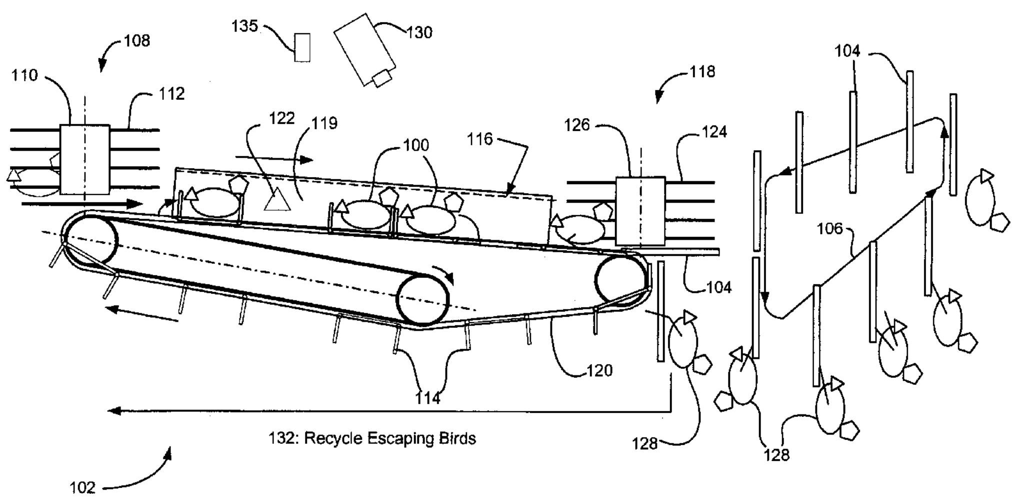
(57) **ABSTRACT**

A system and method for transferring live objects, such as chickens, to a shackle line are presented. The system and method include introducing a plurality of live objects to a singulator. The singulator isolates the individual live objects and places them in a pallet on a conveyor. The system may detect and remove cadavers from amongst the live objects. The conveyor leads the live objects to a grasper. The grasper positions the legs of the live objects so that a shackler can secure the legs of the live objects with a shackle. The live objects and the shackle are then inverted and passed on to a shackle line. The shackle line may be a kill line buffer or a kill line.

36 Claims, 36 Drawing Sheets
(23 of 36 Drawing Sheet(s) Filed in Color)



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BTG, "Automatic Chicken Shackling," Dec. 1995, Reference: 134332. Pursuant to 37 C.F.R. 1.98(d) this reference was previously disclosed in parent U.S. Appl. No. 09/748,656 and issued as Patent No. 6,623,346.

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Lee, et al. paper entitled "Automation Intelligent Live Transfer" Undated, pp. 1-9.

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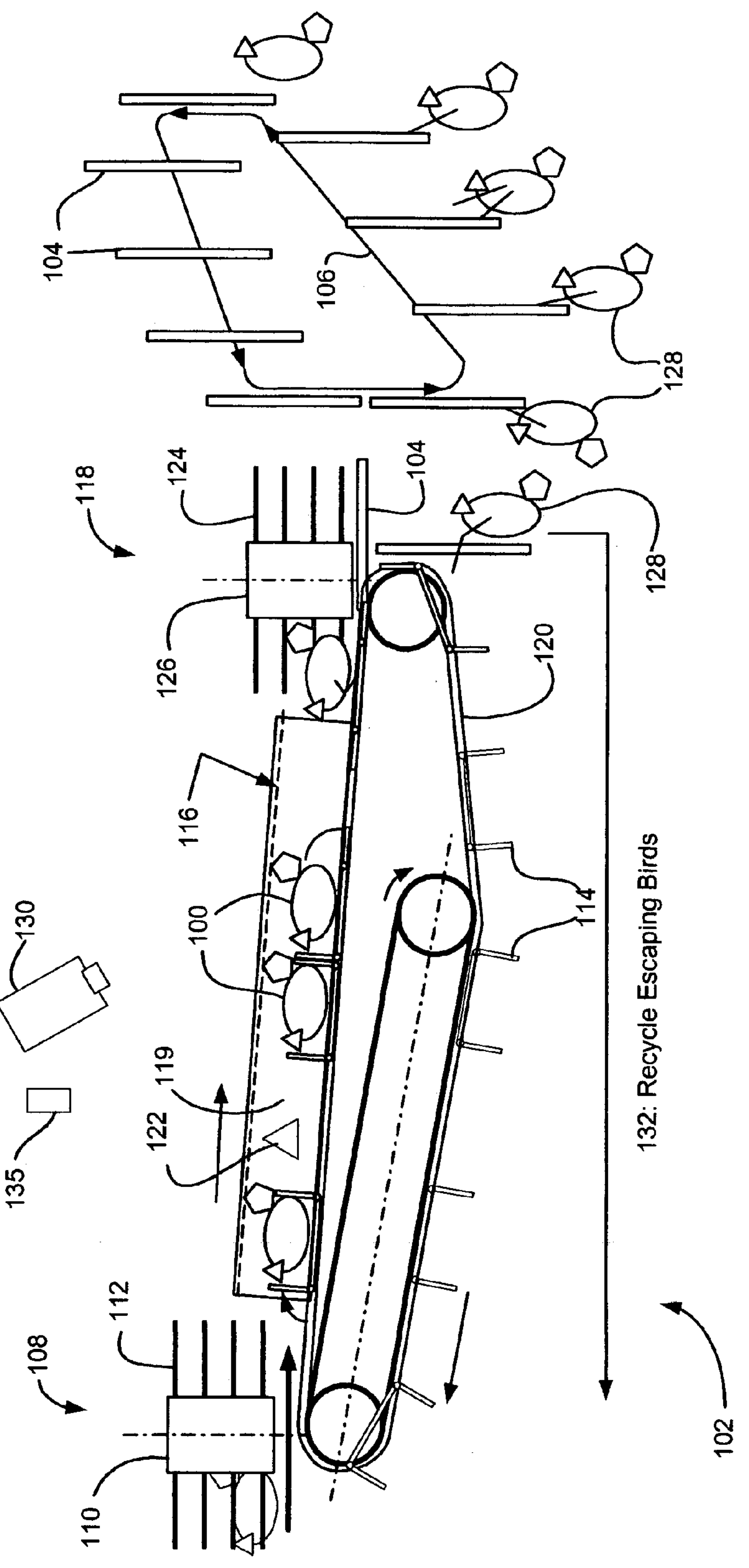
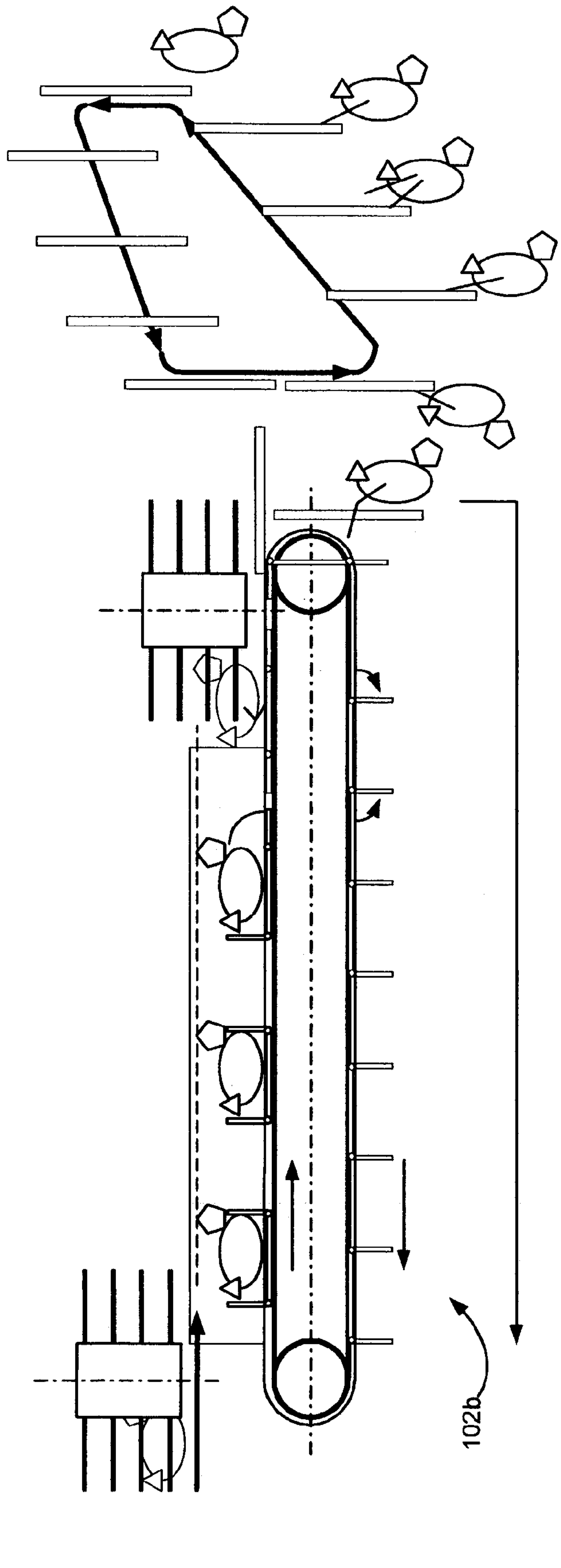
FIG. 1A



104
106
128
118
124
104
126
120
116
100
130
119
122
135
114
112
108
110
102
132: Recycle Escaping Birds

FIG. 1B



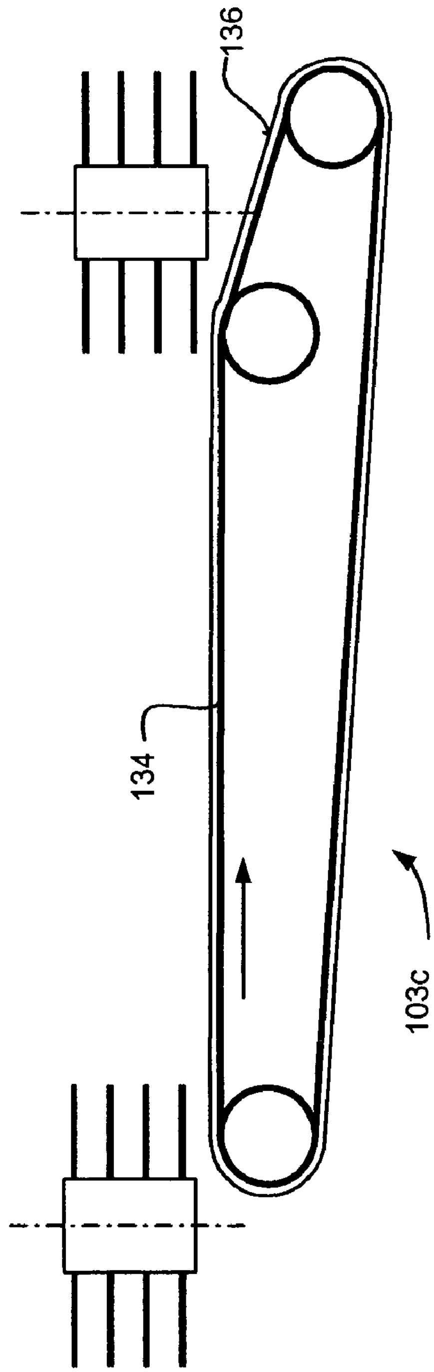


FIG. 1C

FIG. 2
Singulating System

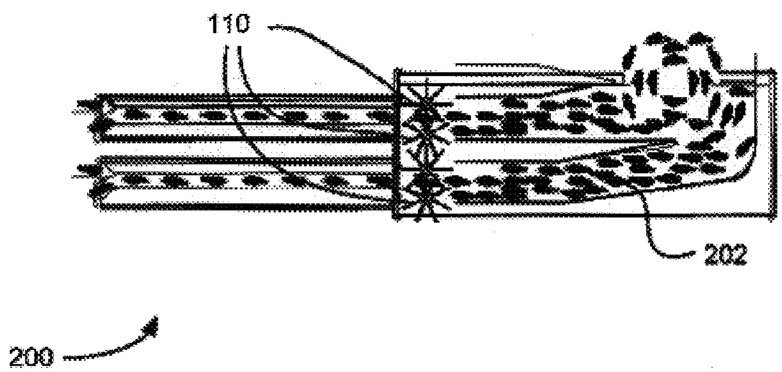


FIG. 3
Pallet

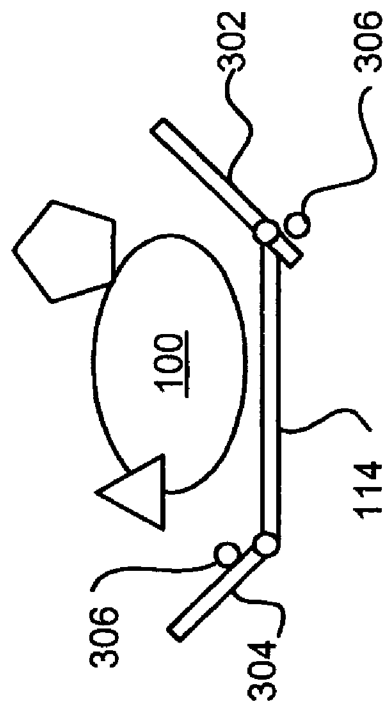


FIG. 4
Leg Gripping

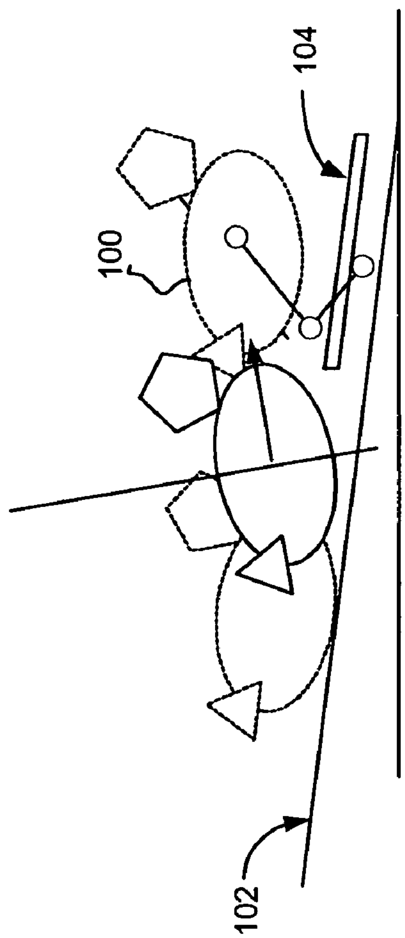


FIG. 5A
Shackle

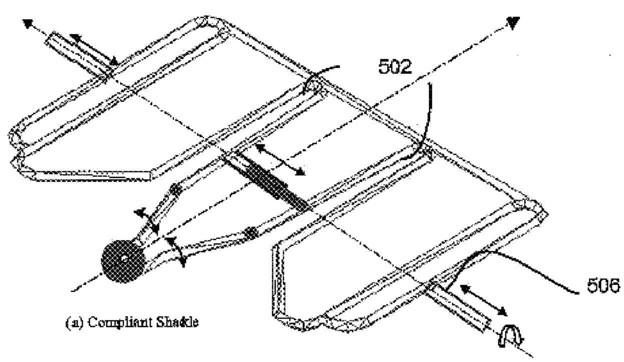


FIG. 5B
Awaiting Shackle

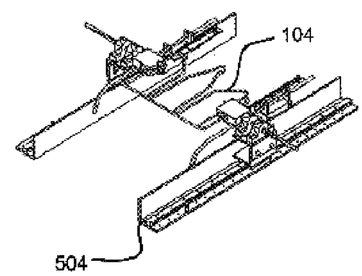
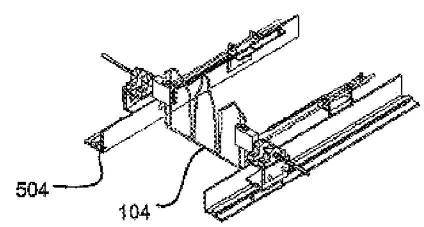
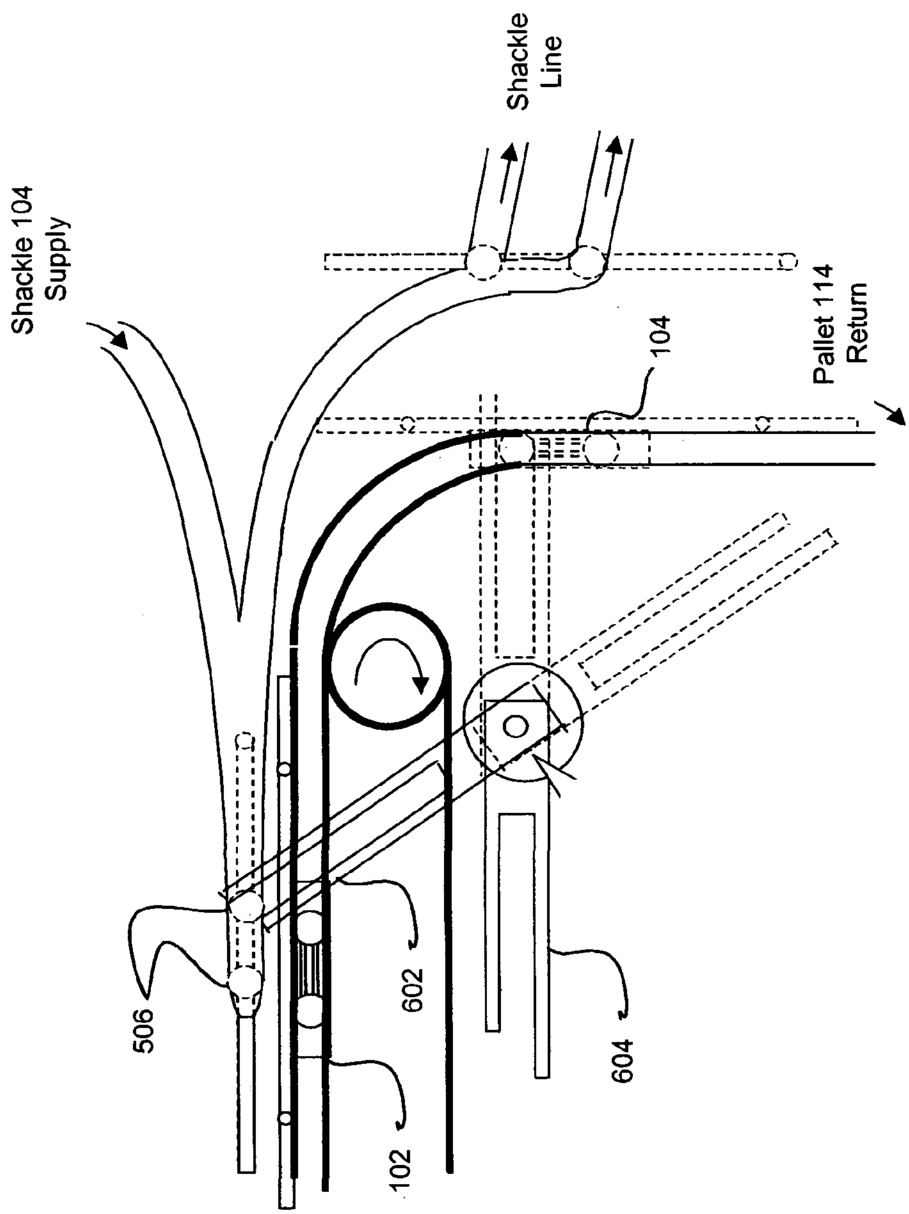


FIG. 5C
Rotated Shackle





Shackle 104
Supply
Shackle
Line
104
Pallet 114
Return
506
602
604
102

FIG. 6

FIG. 7A

Imaging System

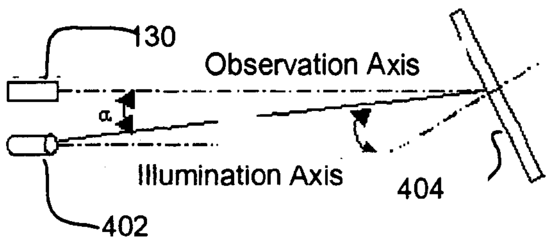


FIG. 7B

Imaging Neural Network

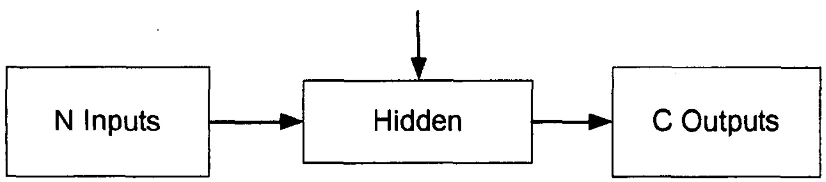


FIG. 7C

Imaging Neural Network

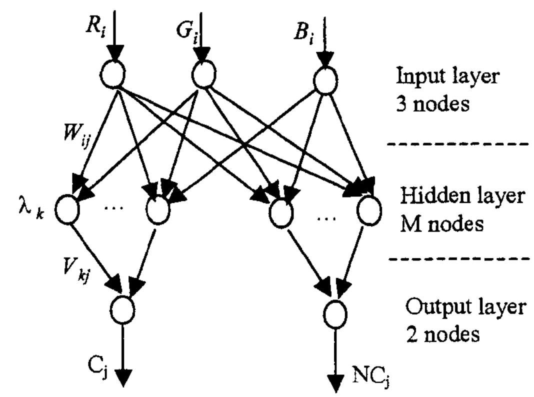


FIG. 8A
Plots for Use with
a Neural Network

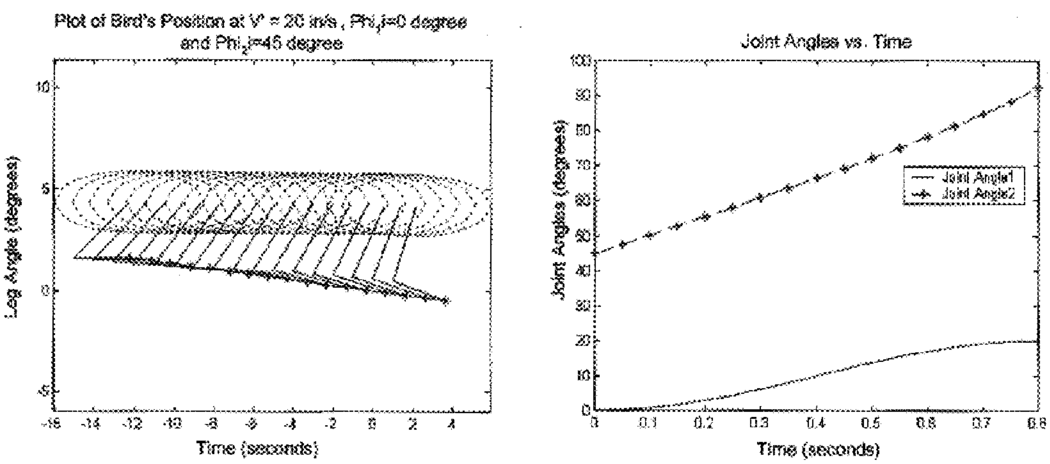


FIG. 8B
Plots for Use with
a Neural Network

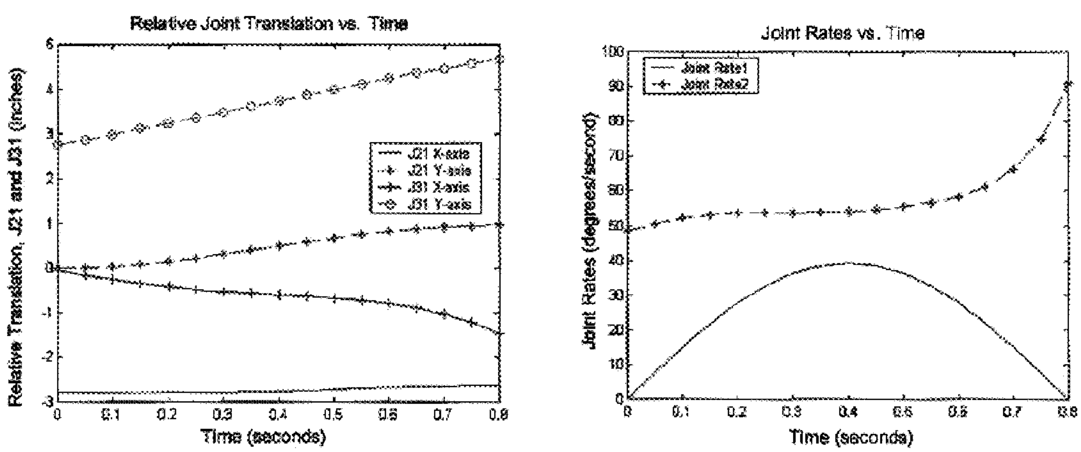


FIG. 8C

Plots for Use with
a Neural Network

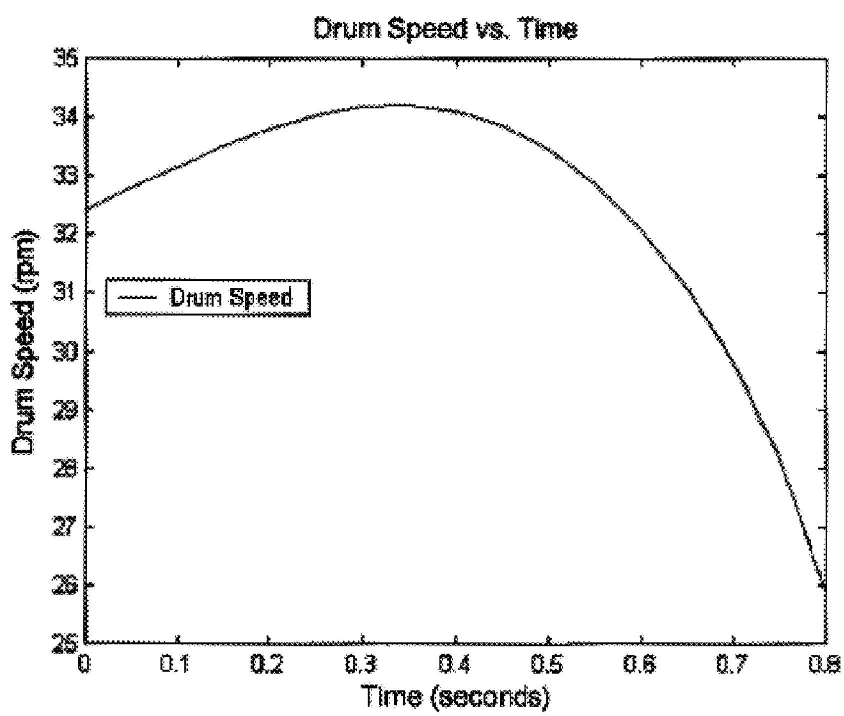


FIG. 9

System Operation Control Sequence

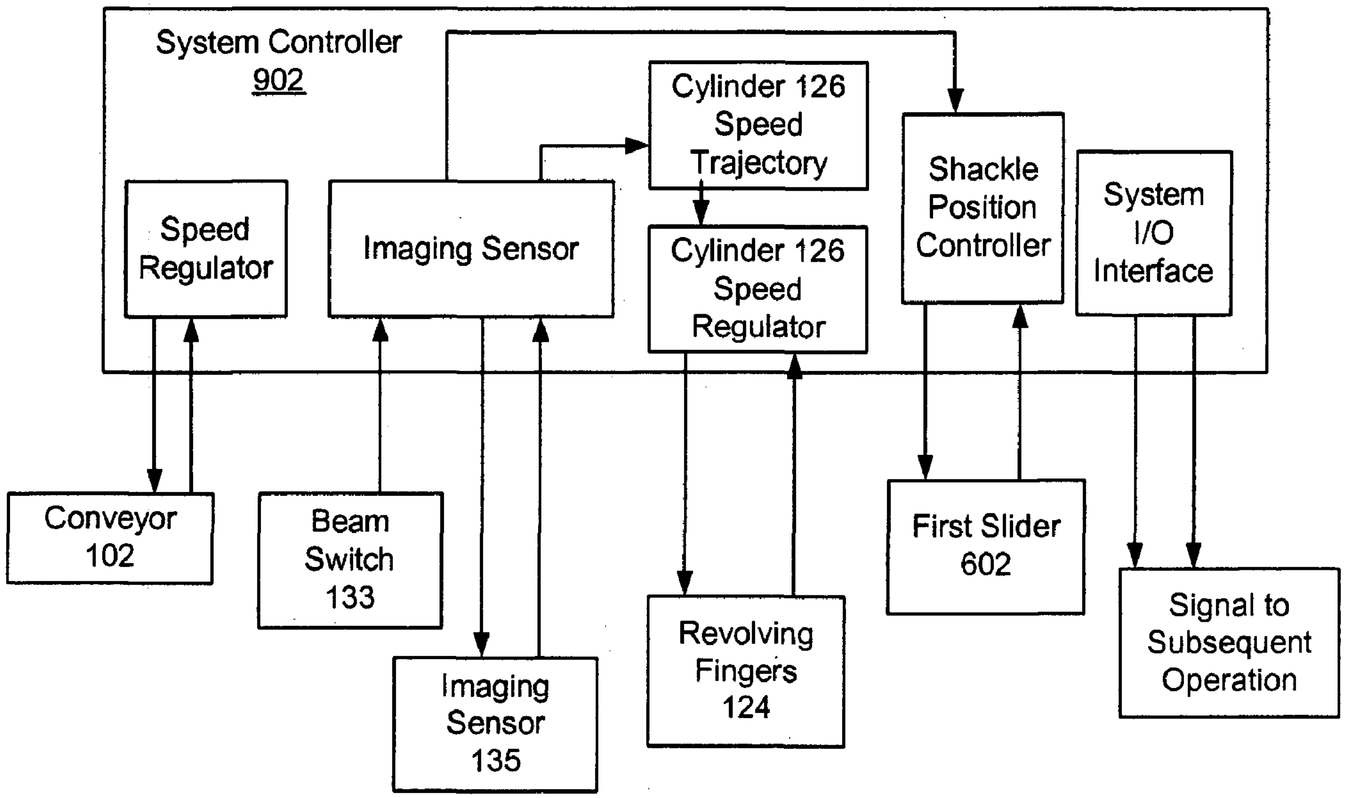


FIG. 10

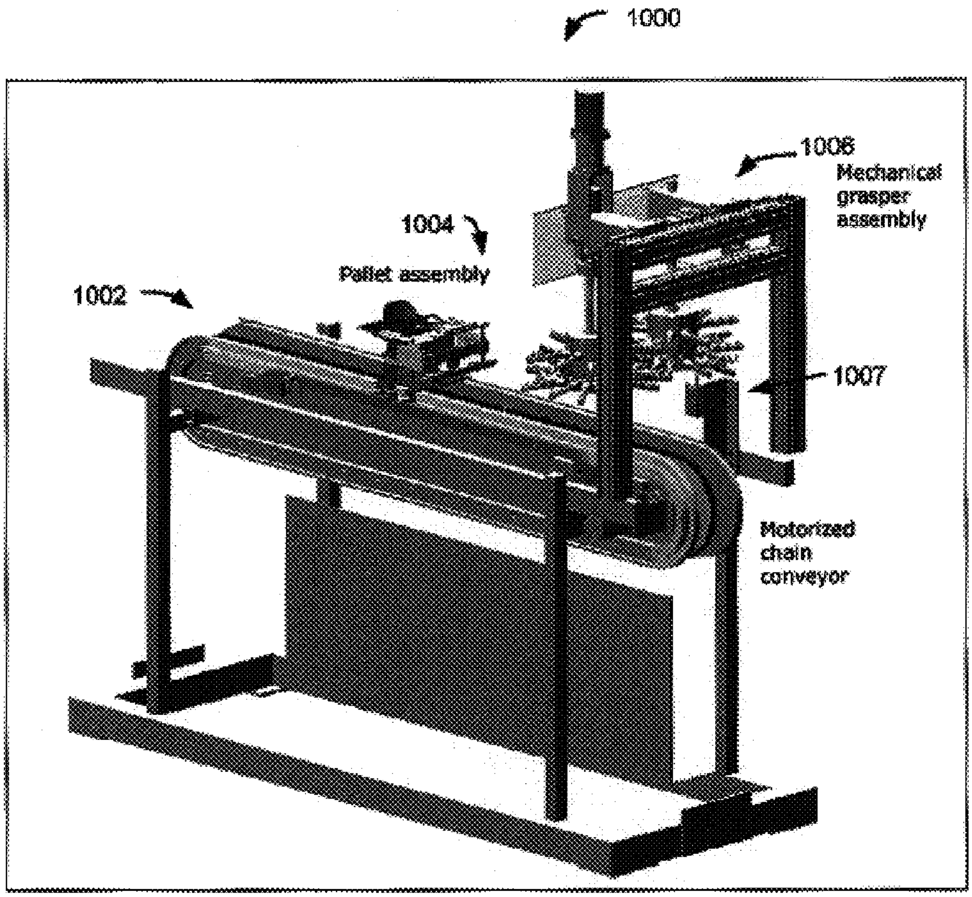
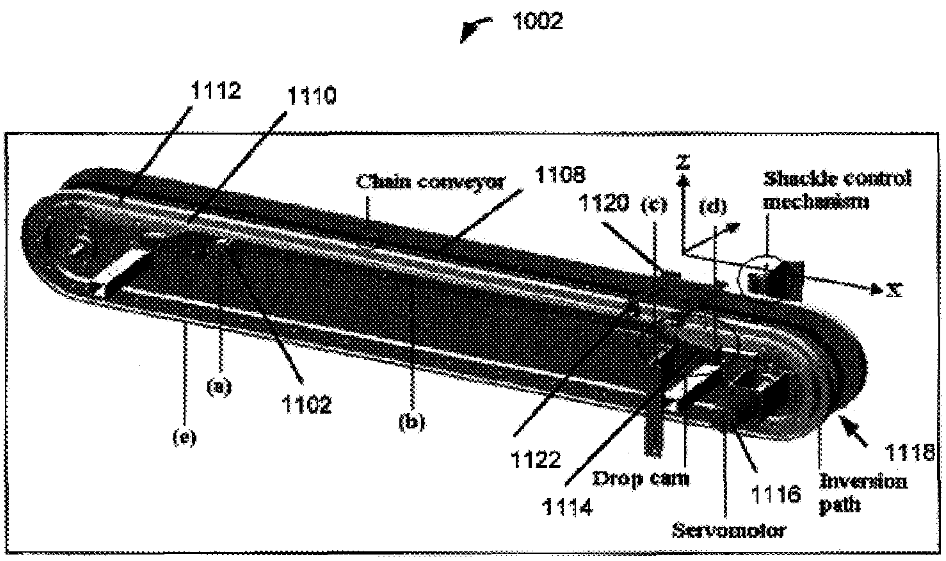

1000
1008
Mechanical grasper assembly
1004
Pallet assembly
1002
1007
Motorized chain conveyor

FIG. 11


1002
1112
1110
Chain conveyor
1108
1120
(c)
(d)
Z
X
Shackle control mechanism
(a)
1102
(e)
(b)
1122
1114
Drop cam
1116
Servomotor
1118
Inversion path

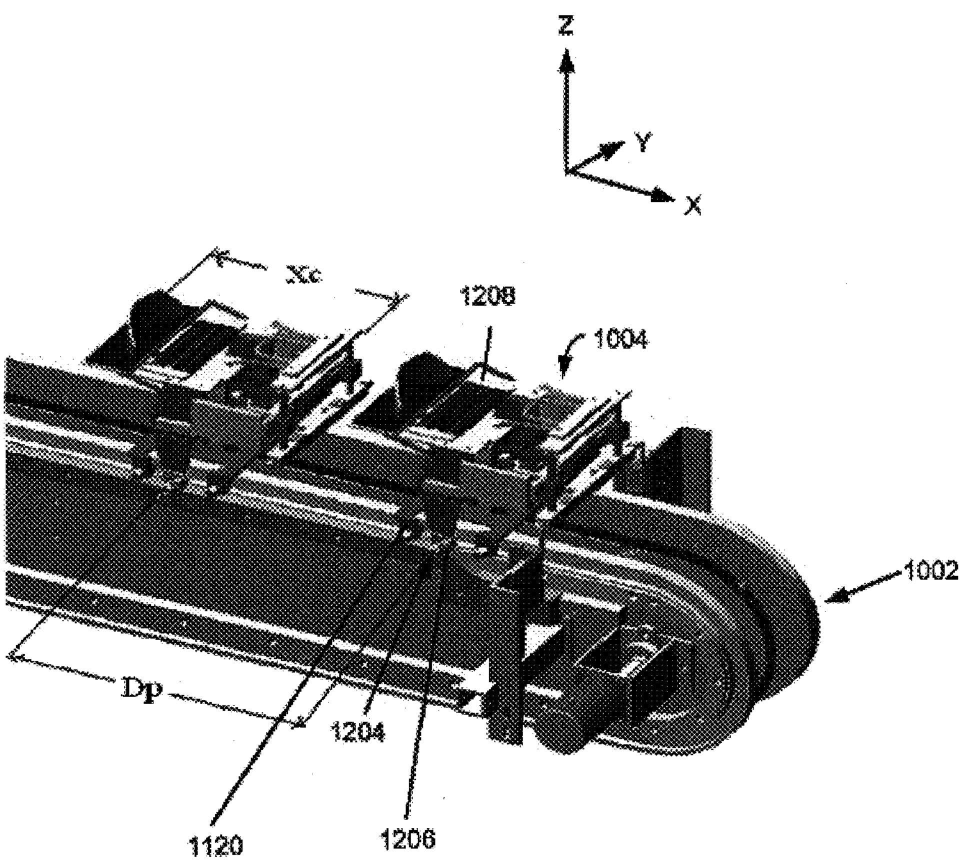


FIG. 12

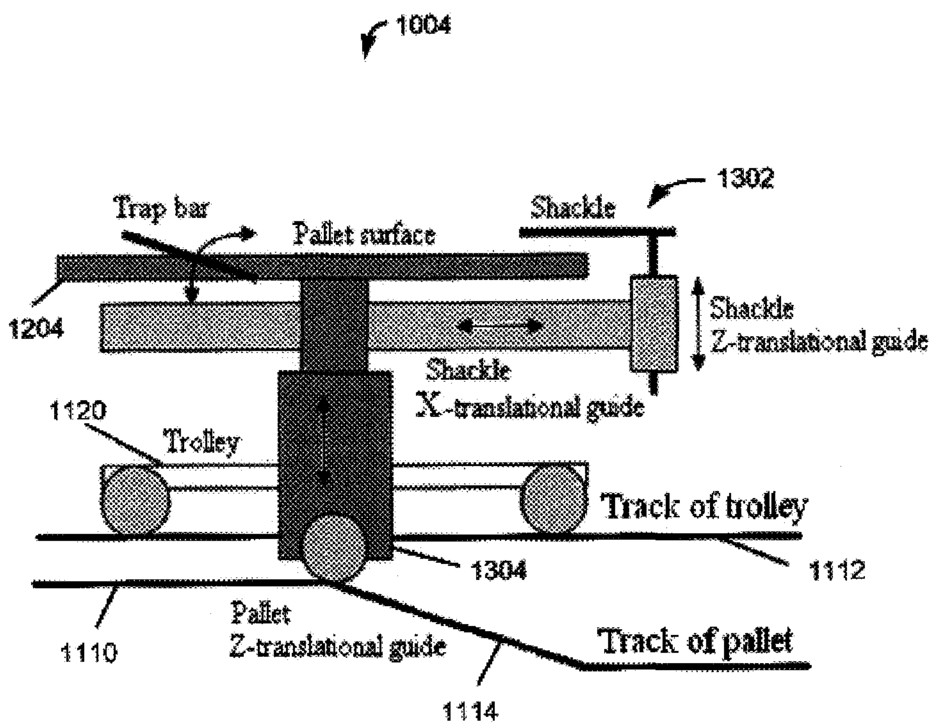

1004
1302
Shackle
Trap bar
Pallet surface
1204
Shackle
Z-translational guide
Shackle
X-translational guide
1120
Trolley
Track of trolley
1304
1112
Pallet
Z-translational guide
1110
Track of pallet
1114

FIG. 13A

FIG. 13B

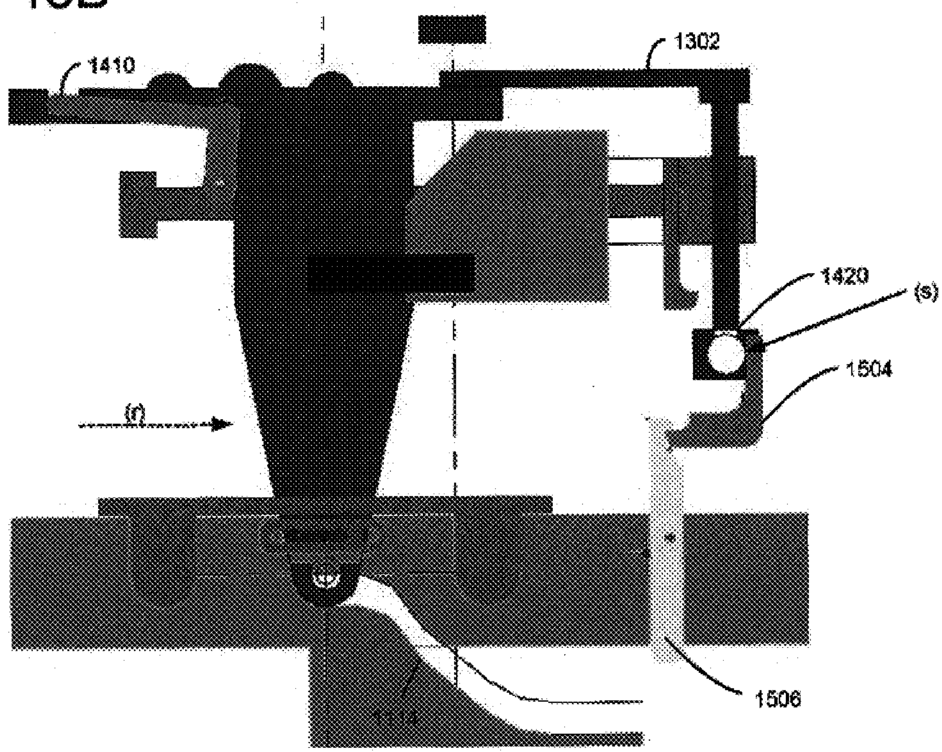


FIG. 13C

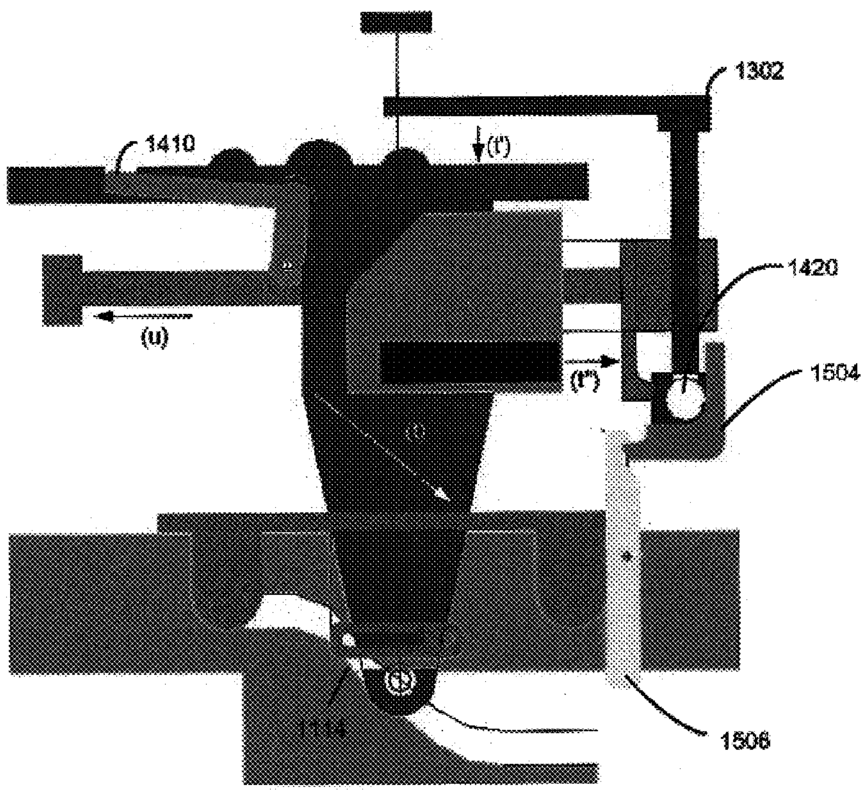


FIG. 13D

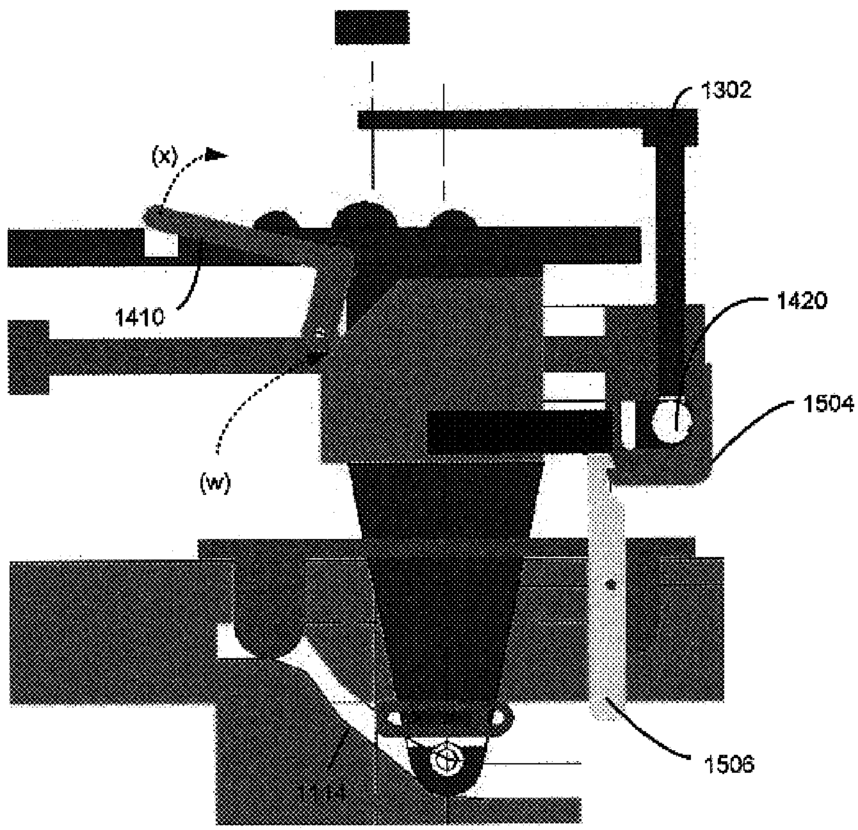


FIG. 13E

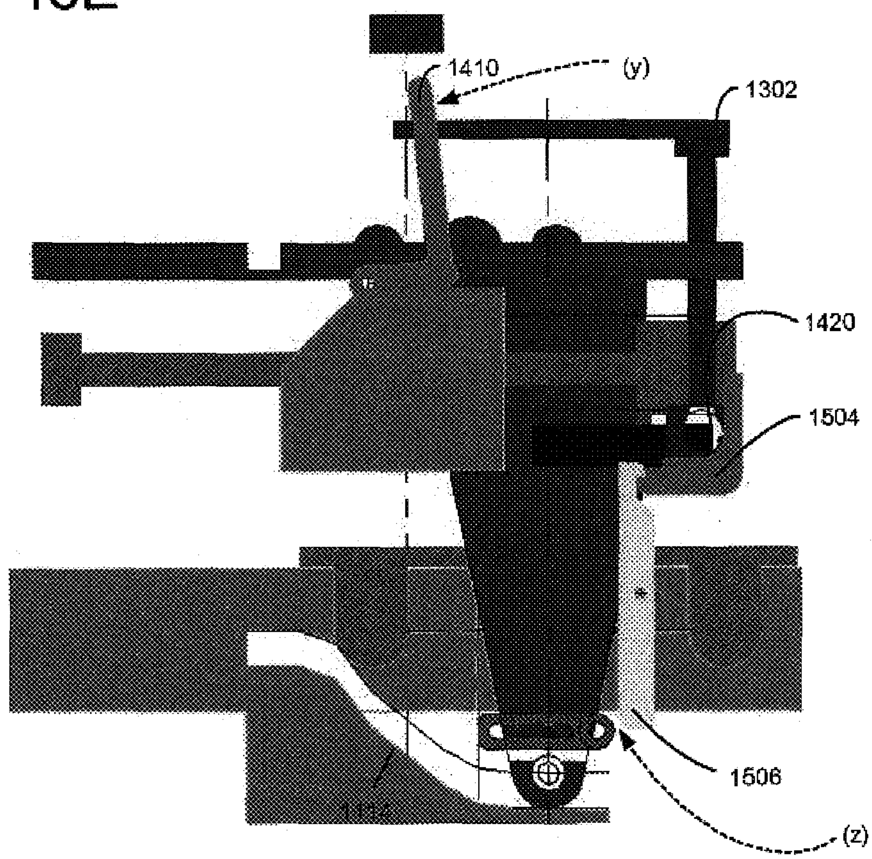


FIG. 14A

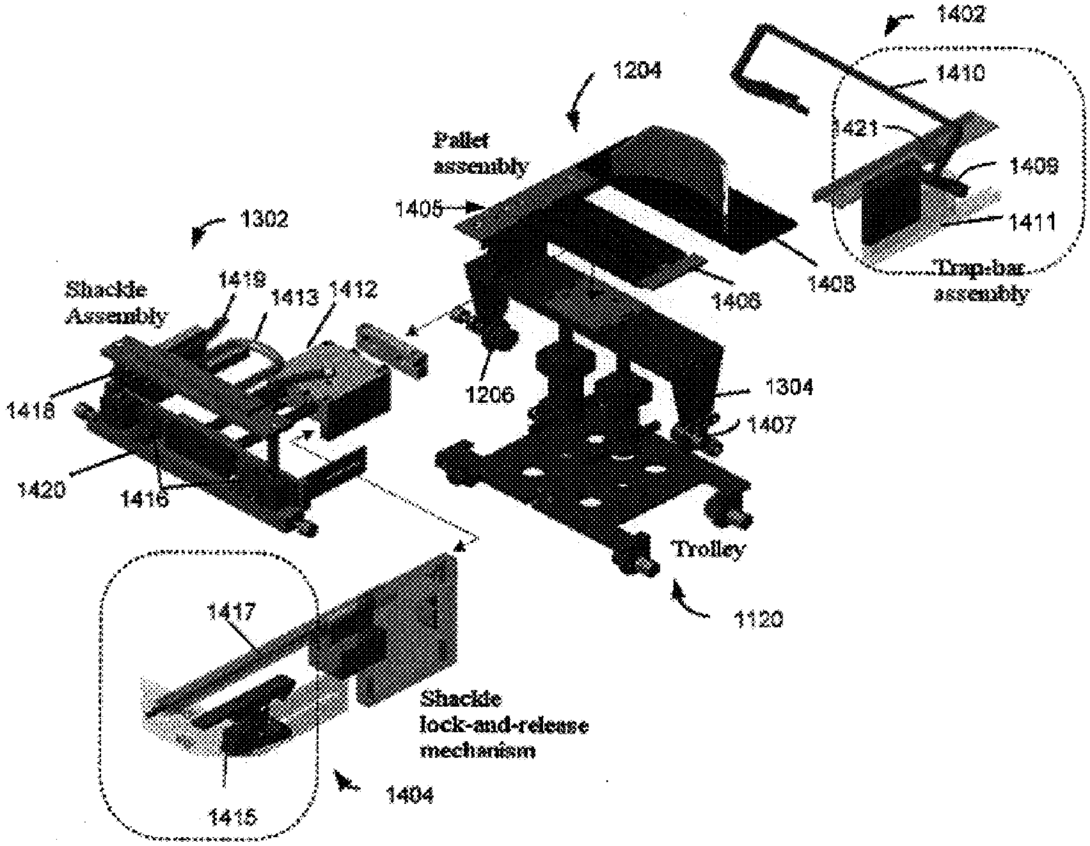

1402
1410
1421
1409
1411
Trap-bar assembly
1204
Pallet assembly
1405
1408
1406
1302
Shackle Assembly
1419
1413
1412
1418
1420
1416
1206
1304
1407
Trolley
1120
1417
Shackle lock-and-release mechanism
1415
1404

FIG. 14B

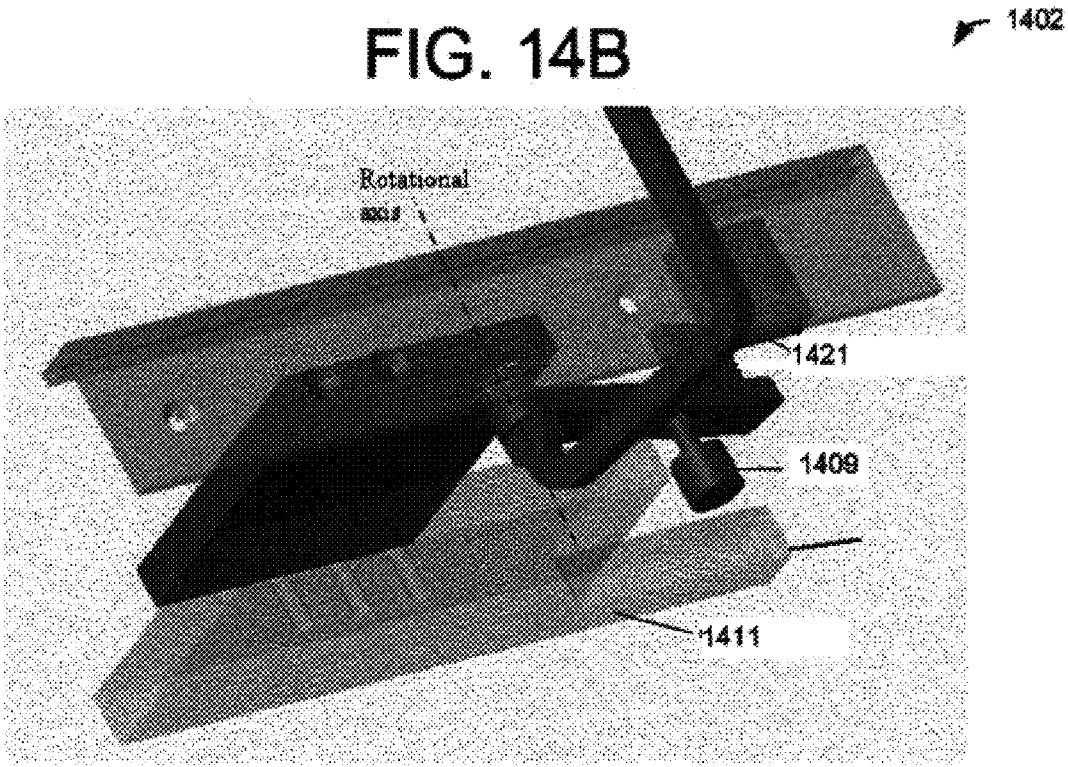


FIG. 14C

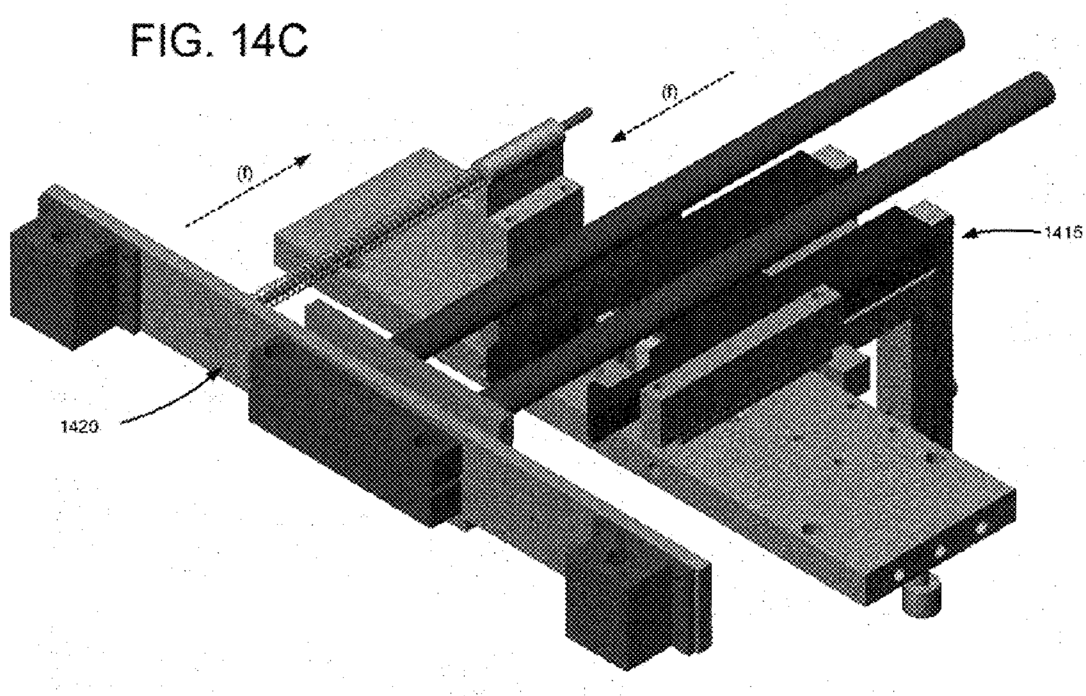
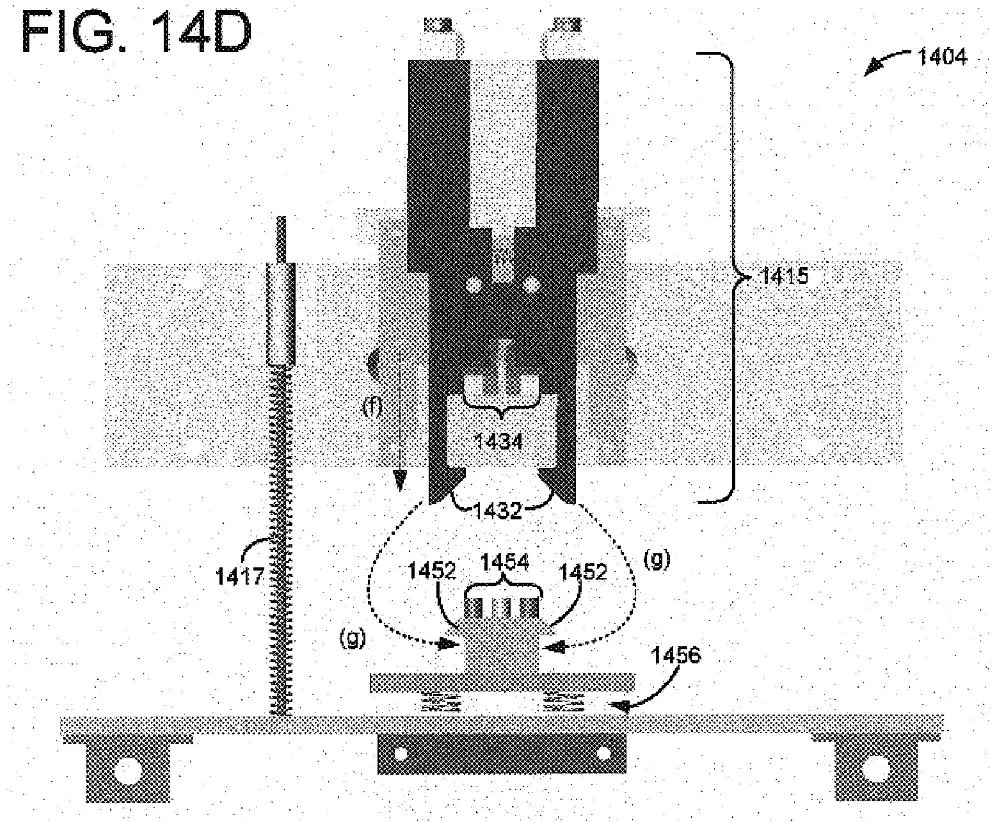


FIG. 14D



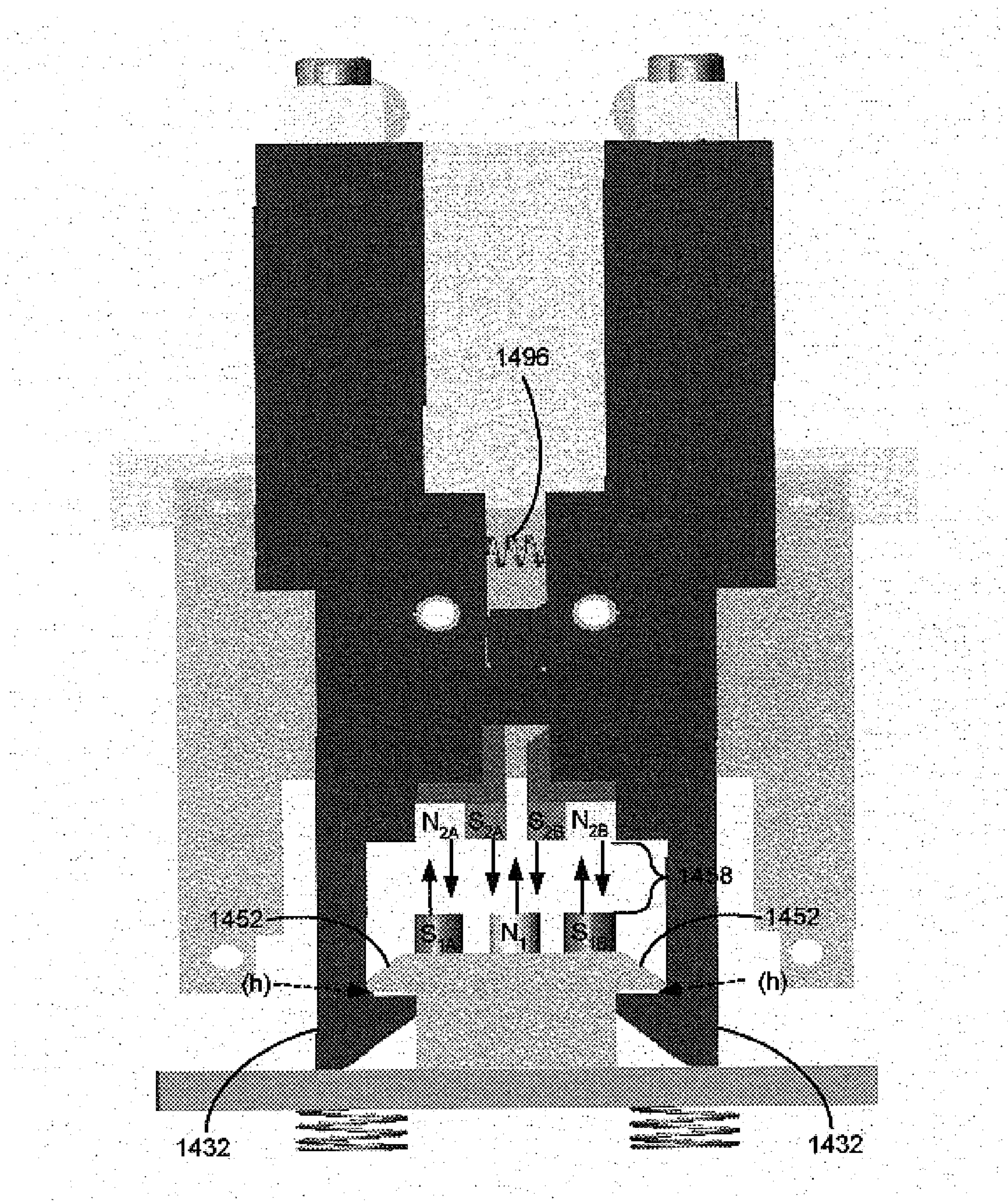


FIG. 14E

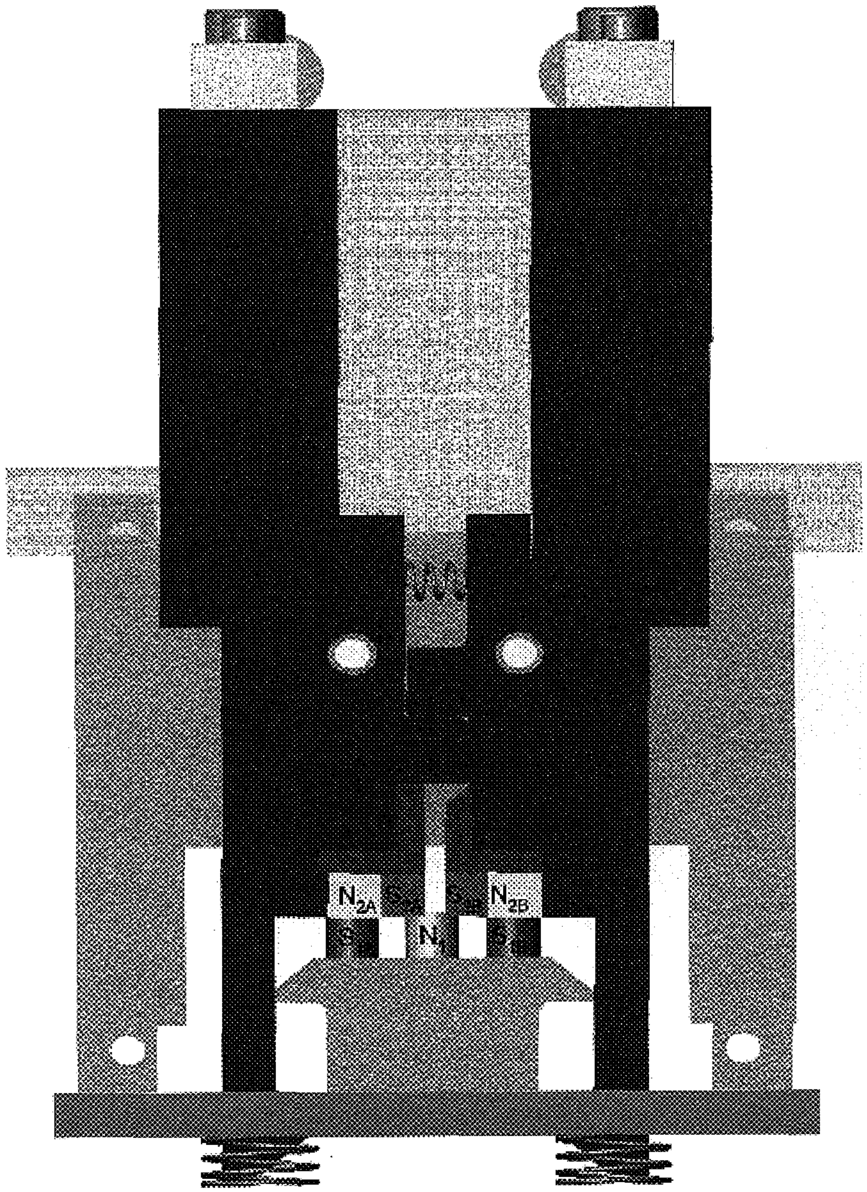
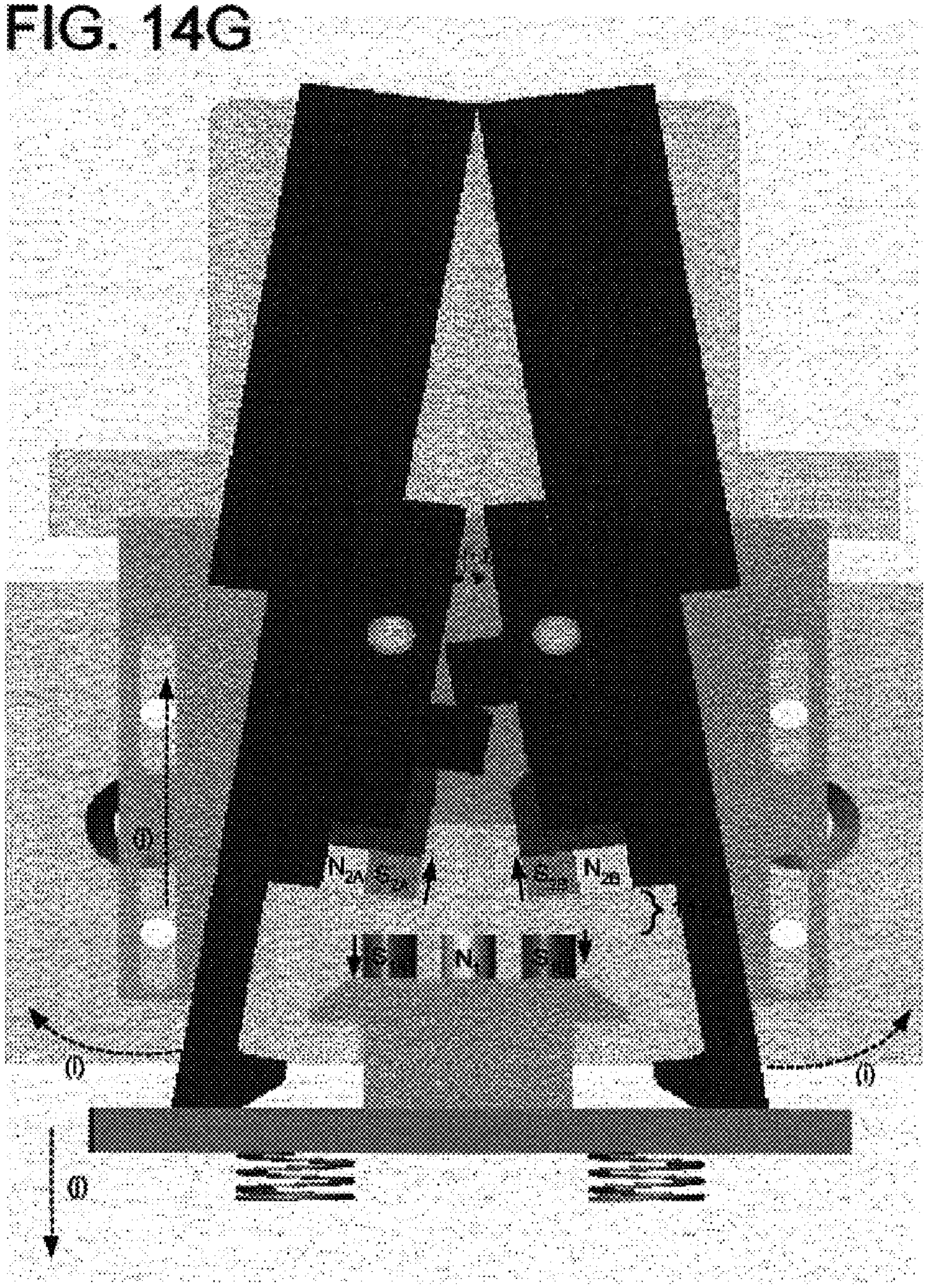


FIG. 14F

FIG. 14G



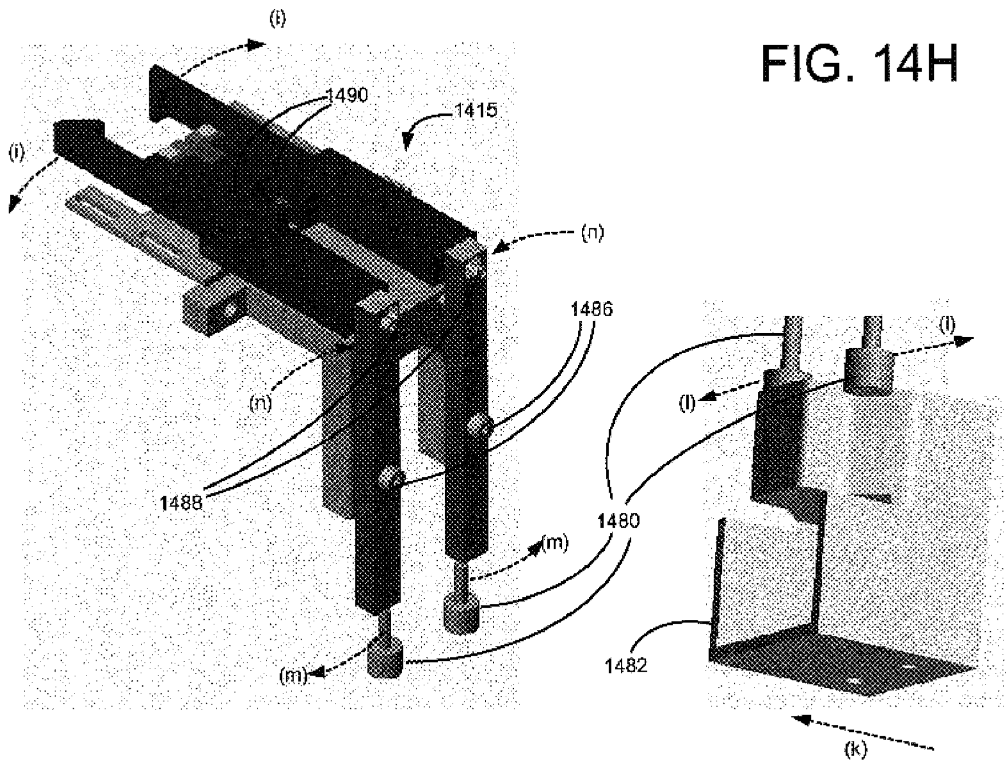


FIG. 14H

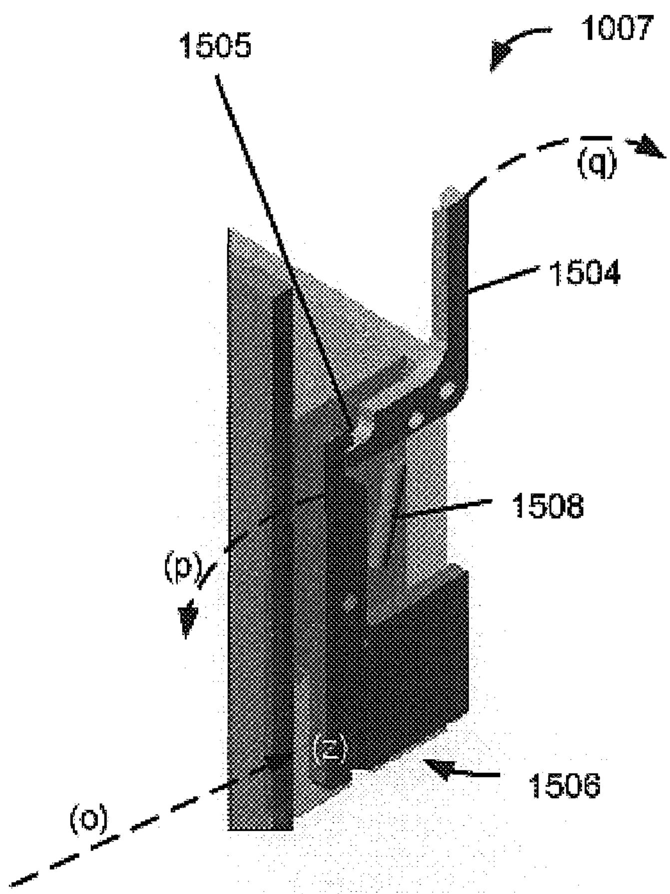


FIG. 15

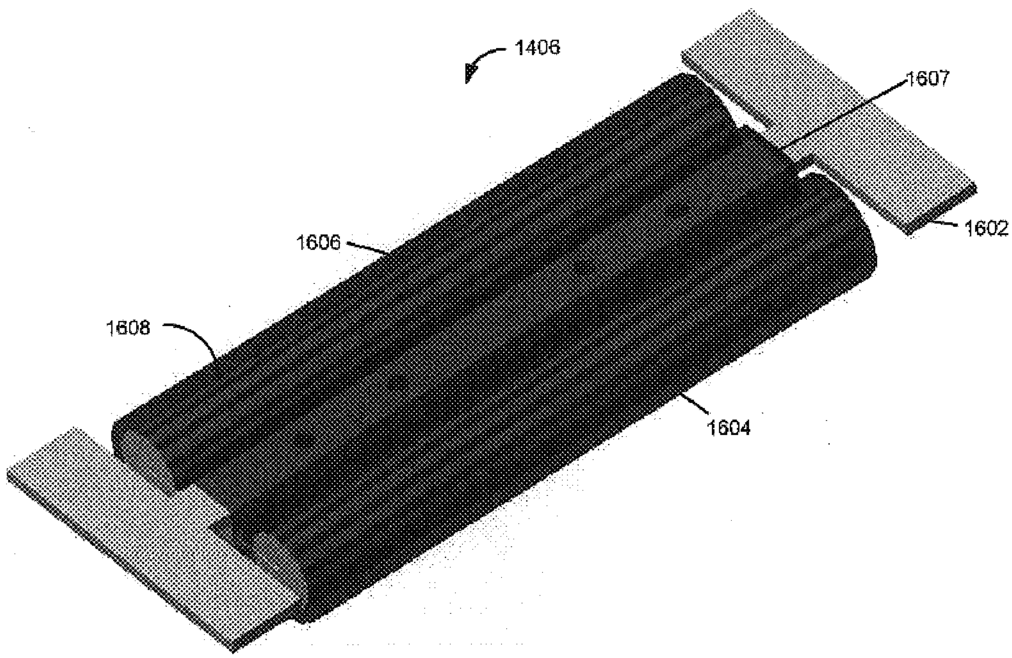


FIG. 16

FIG. 17

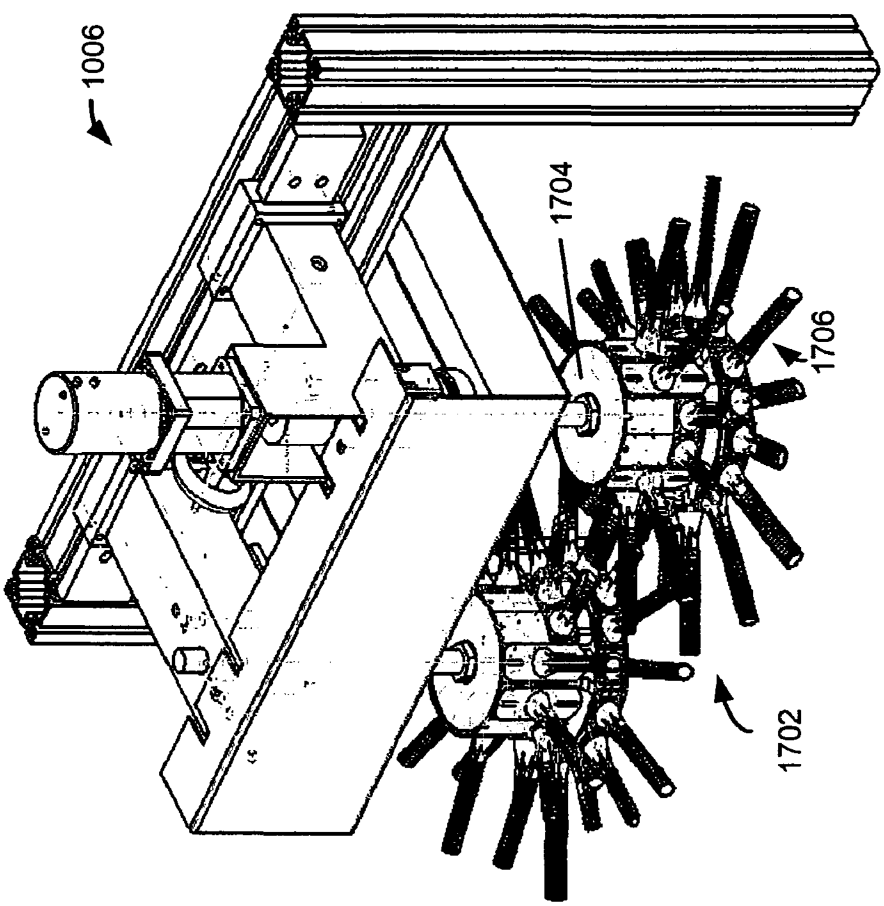


FIG. 18

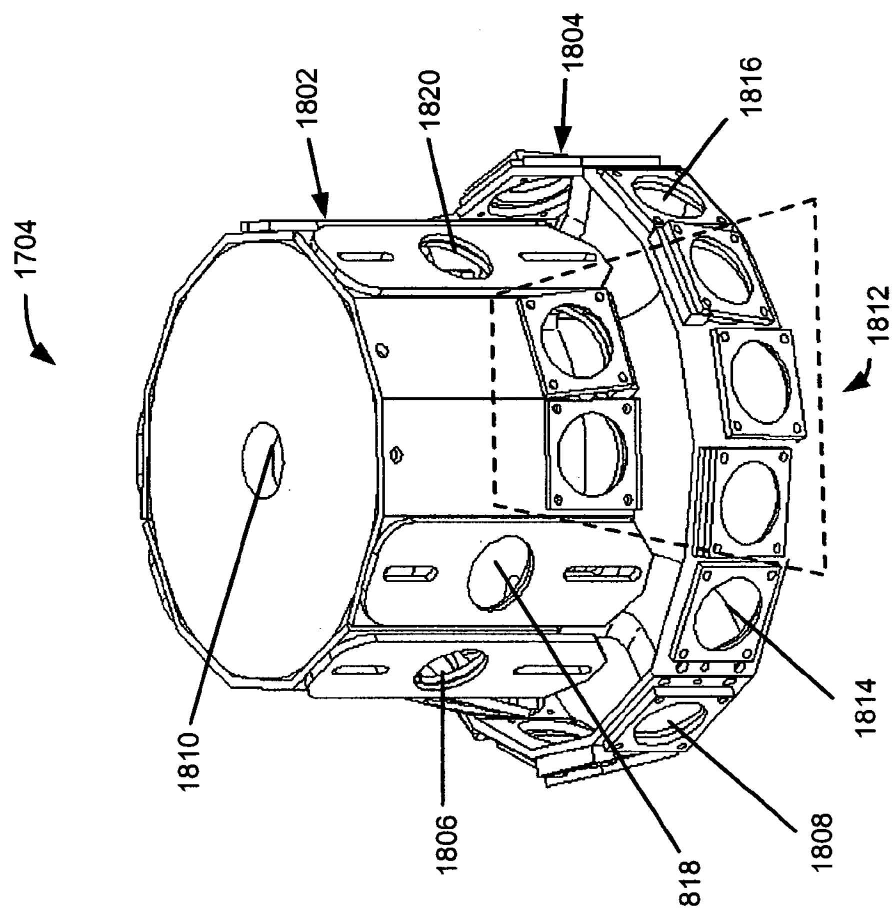
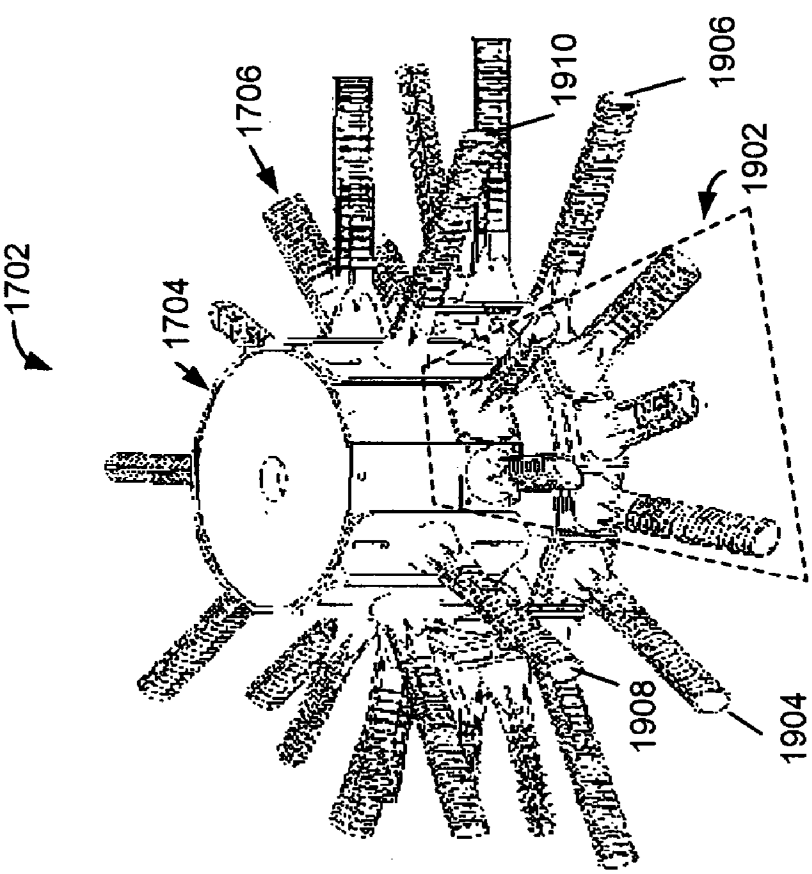


FIG. 19



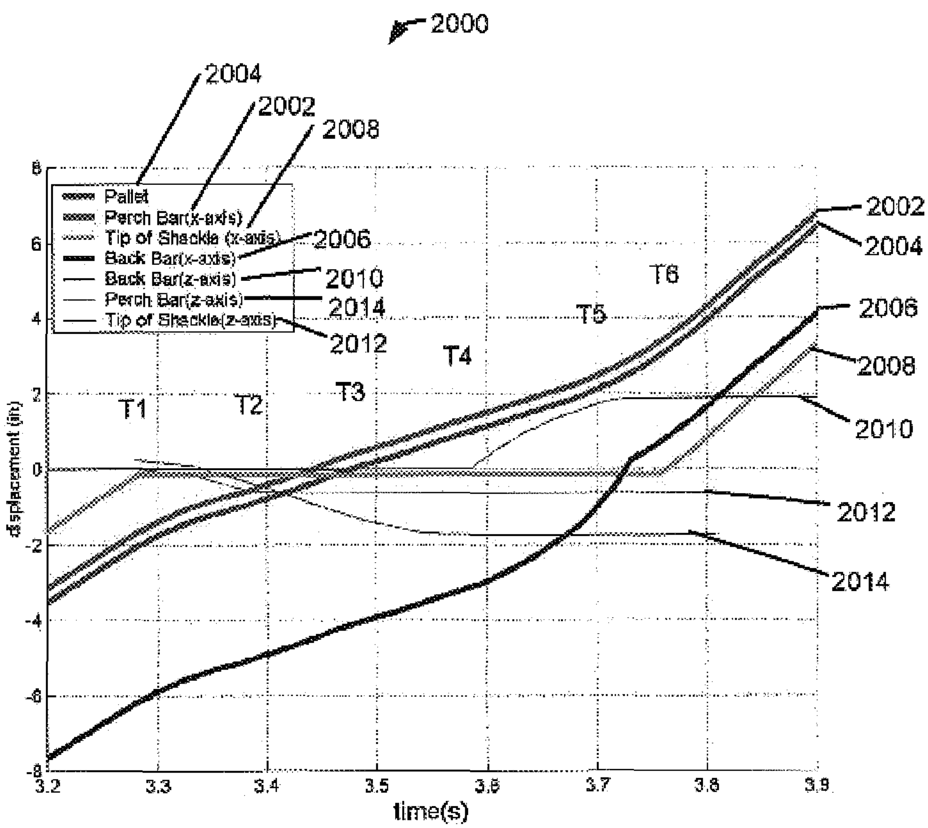
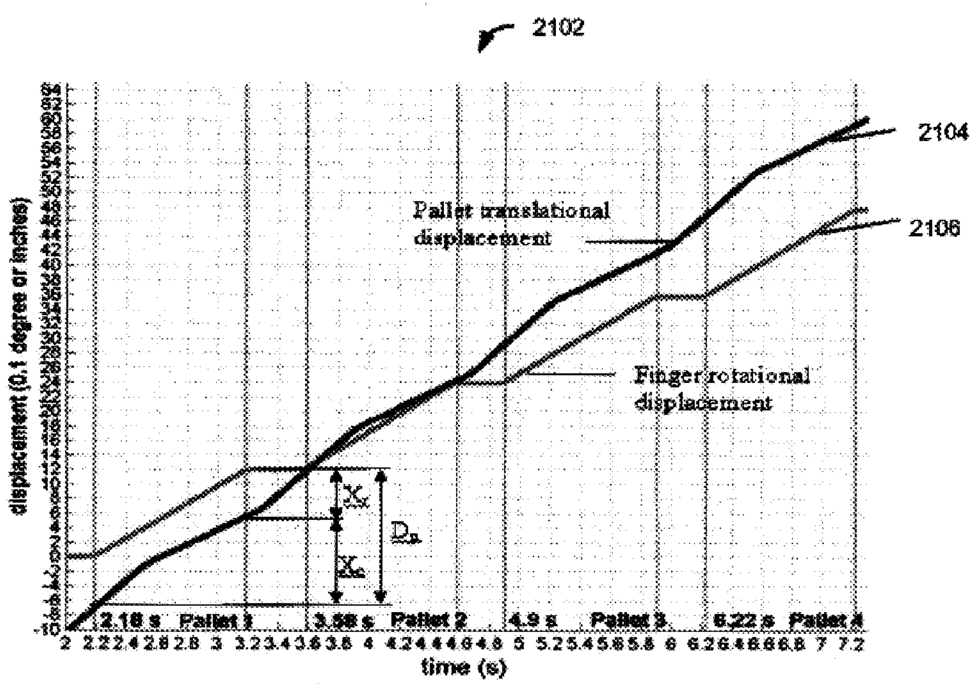

2000
2004
2002
2008
Pallet
Perch Bar(x-axis)
Tip of Shackle (x-axis)
Back Bar(x-axis)
Back Bar(z-axis)
Perch Bar(z-axis)
Tip of Shackle(z-axis)
2006
2010
2014
2012
T1
T2
T3
T4
T5
T6
2002
2004
2006
2008
2010
2012
2014
displacement (in)
time(s)
8
6
4
2
0
-2
-4
-6
-8
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9

FIG. 20

FIG. 21


2102
2104
2106
Pallet translational displacement
Finger rotational displacement
displacement (0.1 degree or inches)
time (s)
2.18 s Pallet 1
3.58 s Pallet 2
4.9 s Pallet 3
6.22 s Pallet 4
X_r
X_c
D_p

AUTOMATED FEET-GRIPPING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part (CIP) of U.S. patent application Ser. No. 09/748,656, filed Dec. 22, 2000 issued as U.S. Pat. No. 6,623,346, which claims priority to four copending U.S. provisional applications all entitled, "Method of Mechanical Transferring Live Broilers from Moving Conveyor to Shackle," having Ser. No. 60/171,990, filed Dec. 23, 1999; Ser. No. 60/177,576, filed Jan. 22, 2000; Ser. No. 60/197,362, filed Apr. 15, 2000; and Ser. No. 60/252,987, filed Nov. 23, 2000.

This application also claims priority to U.S. provisional patent application entitled, "Automated Feet-Gripping System," having Ser. No. 60/444,861, filed Feb. 4, 2003, which is incorporated herein by reference in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

The U.S. government and the Georgia Agricultural Technology Research Program may have a paid-up license in this invention and the right in limited circumstances to require the patent owner to license others on reasonable terms as provided for by the terms of U.S. Poultry and Eggs Association (U.S. P&E) Project Nos. 333, 413 and 446, both entitled, "Intelligent Automated Transfer of Live Birds to Shackle Line."

COPYRIGHT NOTICE

TECHNICAL FIELD

The present invention is generally related to the transfer of live objects to shackle lines and, more particularly, is related to a system and method for organizing, restraining and transferring live chickens from a farm to a processing facility.

BACKGROUND OF THE INVENTION

Manual handling of live birds is a hazardous and unpleasant task. There are potentials for a variety of injuries to human handlers since the birds tend to flail about when they are caught. Potential injuries include: cuts and scratches that can easily become infected in a chicken farm environment; a variety of respiratory and visual ailments resulting from the high level of dust and feathers; hands or fingers can get caught in moving shackle lines; and repetitive motion disorders. The unpleasantness associated with the manual handling of live birds results in high employee turnover rates at some plants. The high turnover rate results in the need to constantly retrain new employees. In addition, it is difficult to attract new workers to the job. In addition, manual handling of live birds may lead to bruising and downgrading of birds.

Despite the drawbacks, live birds are usually handled manually (from hatching through processing). The reason for manual handling is handling of live birds by automation presents unique challenges, such as the following: (1) Unlike handling of non-reactive objects, both the mechanical forces and the bird's natural reflexes contribute to the overall dynamics; (2) Live birds vary in size and shape, making handling automation difficult; (3) Since both the birds and the grasping fingers are compliant, contact forces depend on the surface geometry and are position/orientation dependent; and (4) In order to justify the need for automation from a cost-savings viewpoint, the mechanical devices must perform the repetitive task in a shorter amount of time, and with more accuracy, than a human.

Thus, a heretofore unaddressed need exists in the industry to address the aforementioned deficiencies and inadequacies.

The patent or application file contains at least one drawing executed in color. Copies of this patent or patent application publication with color drawings(s) will be provided by the Office upon request and payment of the necessary fee.

SUMMARY OF THE INVENTION

The present invention provides devices, systems, and methods for transferring live objects to a shackle line.

Briefly described, in architecture, one such system, among others can be implemented as follows. A plurality of live objects are introduced to a singulator. The singulator isolates the individual live objects and places them in a pallet on a conveyor. The system may detect and remove cadavers from amongst the live objects. The conveyor leads the live objects to a grasper. The grasper positions the legs of the live objects so that a shackler can secure the legs of the live objects with a shackle. The live objects and the shackle are then inverted and passed on to a shackle line. The shackle line may be a kill line buffer or a kill line.

The present invention can also be viewed as providing methods for automatically transferring a plurality of live objects with legs to a shackle line. In this regard, one such method, among others can be broadly summarized by the following steps: isolating each of the plurality of live objects; conveying the live objects to a grasper; positioning the isolated live objects with the legs of the live objects extended; securing the legs of the live objects to one of a plurality of shackles; inverting the live objects; and hanging each of the isolated live objects by the shackle.

Other devices, systems, methods, features, and advantages of the present invention will be or become apparent to one with skill in the art upon examination of the following drawings and detailed description. It is intended that all such additional systems, methods, features, and advantages be included within this description, be within the scope of the present invention, and be protected by the accompanying claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention can be better understood with reference to the following drawings. The patent or application file contains at least one drawing executed in color. Copies of this patent or patent application publication with the color drawing(s) will be provided by the Office upon request and payment fee. The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present invention.

Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

FIG. **1**A is a side view of a preferred embodiment of the system for transferring live objects to a shackle line including a declined conveyor.

FIG. **1**B is a side view of a second embodiment of the system for transferring live objects to a shackle line including a relatively flat conveyor.

FIG. **1**C is a third embodiment of the system for transferring live objects to a shackle line including a conveyor with a relatively flat portion and a declined portion.

FIG. **2** is a top view of the singulating system for transferring live objects to a shackle line of FIGS. **1**A–**1**C.

FIG. **3** is side view of a pallet that is attached to the conveyor of the system for transferring live objects to a shackle line of FIGS. **1**A–**1**C.

FIG. **4** is a diagram showing the lifting of a live object and the securing of the legs of the live object with a shackle that is a part of the system for transferring live objects to a shackle line of FIGS. **1**A–**1**C.

FIG. **5**A. is a perspective view of the shackle for securing the legs of a live object shown in FIG. **4**.

FIGS. **5**B and **5**C show perspective views of the shackle and shackle support awaiting the arrival of a live object (FIG. **5**B) and the rotated shackle and shackle support (FIG. **5**C) rotated as it would be while securing the legs of the live object.

FIG. **6** is a side view of the system for synchronizing the inversion of the shackle of FIG. **4**, the live object, and the pallet of FIG. **3**.

FIG. **7**A is an imaging system for determining the orientation of the live objects of the system for transferring live objects to a shackle line of FIGS. **1**A–**1**C.

FIGS. **7**B and **7**C show a block and a node diagram of a neural network that shows one system for controlling the operation of the system for transferring live objects to a shackle line of FIGS. **1**A–**1**C.

FIGS. **8**A–**8**C are sample plots for use in controlling the system for transferring live objects to a shackle line of FIGS. **1**A–**1**C through the use of the neural network of FIGS. **7**B and **7**C.

FIG. **9** is a block diagram of a system operation control sequence for controlling the operation of the system for transferring live objects to a shackle line of FIGS. **1**A–**1**C.

FIG. **10** is a plan view depicting a system for an automated feet-gripping system in accordance with a preferred embodiment of the invention.

FIG. **11** is a schematic diagram of a motorized chain conveyor in accordance with a preferred embodiment of an automated feet-gripping system.

FIG. **12** is a schematic diagram of a motorized chain conveyor having automated feet-gripping systems thereon in accordance with a preferred embodiment of the invention.

FIGS. **13**A through **13**E are schematic diagrams of an illustrative example of degrees of movement of an automated feet-gripping system in accordance with a preferred embodiment of the invention.

FIGS. **14**A through **14**H are illustrative examples of schematic diagrams of an automated feet-gripping system in accordance with a preferred embodiment of the invention.

FIG. **15** is a schematic diagram of a shackle control mechanism in accordance with a preferred embodiment of the invention.

FIG. **16** is a schematic diagram of a perch bar of an automated feet-gripping system in accordance with a preferred embodiment of the invention.

FIG. **17** is a schematic view of an illustrative embodiment of a grasper system of an automated feet-gripping system in accordance with a preferred embodiment of the invention.

FIG. **18** is a schematic view of an illustrative embodiment of a supporting structure of a grasper system in accordance with a preferred embodiment of the invention.

FIG. **19** is a schematic view of an illustrative embodiment of a supporting structure having a plurality of fingers of a grasper system of FIG. **17** in accordance with a preferred embodiment of the invention.

FIG. **20** is a graph illustrating an example of timing control in accordance with a preferred embodiment of the invention.

FIG. **21** is a graph illustrating an example of a displacement timing diagram in accordance with a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1**A is a side view of a preferred embodiment of the system for transferring live objects to a shackle line including a declined conveyor. FIG. **1**A shows an automated system for transferring live objects, such as chickens **100**, from a moving non-slip conveyor **102** to shackles **104** on a shackle line **106**. A typical cycle of the system begins with the chickens **100** being unloaded from cages (not shown) onto a moving singulating entry conveyor (**202** of FIG. **2**). The singulating conveyor **202** transfers the birds to a singulator **108**. The singulator **108** includes two separate hollow cylinders **110** (only one shown in the side view of FIG. **1**). Each hollow cylinder **110** includes a set of counter-rotating fingers **112** mounted on the hollow cylinders **110**.

The singulator **108** serves two functions. The first function is to cause the chickens **100** to stand. The second function is to isolate the chickens **100** so that they leave the rotating fingers **112** one at a time. As the cylinders **110** are rotated, tangential motion disperses the chickens **100** over the periphery of the rotating cylinders **110** while centripetal and gravitational forces cause the chickens **100** to move away from the cylinders **110** and drop onto the moving conveyor **102**. The singulator **108** may also include a re-orienter (not shown) that may sense the direction the chickens **100** are facing and turn some chickens **100** so that all chickens **100** are facing forward.

Each of the cylinders **110** is driven by independent servomotors (not shown) rotating in opposite direction. The cylinders **110** each support a number of columns of evenly spaced rubber fingers **112**. The use of counter-rotating fingers for electronic counting of live objects is known to those skilled in the art. The fingers **112** are compliant to accommodate the range of chickens **100**. The fingers **112** are generally oval shaped to provide stiffness in the plane of travel and pliancy perpendicular to the plane of travel. The fingers generally have a rough surface to assist in maintaining contact with the chickens **100**. The cylinders **110** are spaced sufficiently apart that only one chicken can pass through at a time.

The singulator **108** deposits the isolated chickens in one of a number of pallets **114** secured to the conveyor **102**.

The chicken **100** is then transported on the conveyor **102** in the pallet **114** through an enclosed space with a low ceiling **116** where the chicken is confined to sit. Confining the chicken **100** to sit leads to a more uniform posture as the chickens **100** approach the grasper **118**. The enclosed space is bounded by a pair of walls **119** to prevent the chickens **100** from voluntarily re-orienting themselves. The pallets **114** may be secured to the conveyor **102** frame by a rail **120**.

The singulated chickens **100** may then be led through a cadaver detection system (CDS) consisting of a light emitting diode (LED) **122** and a photo-diode light detector (not shown). Each live chicken **100** immediately exiting the singulator **108** will be in a standing position distinctly different from that of any cadavers, this information is used to detect and remove cadavers from the automated system. The pair of walls **119** are transparent where necessary for the operation of the LED **122**.

The singulated live chickens **100** are directed to a grasper **118** that includes a second system of counter-rotating fingers **124**, which gently constrain the chickens **100** to allow the shackling to take place. Near the end of the conveyor **102**, while the revolving fingers **124** of the grasper **118** continuously roll the chicken **100** forward, the leg kinematics of the chicken **100** are manipulated by appropriately controlling the grasper cylinder **126** speed relative to the conveyor **102** speed such that both legs of the chicken **100** are directed into the graspers **502** (of FIG. **5**A) of an awaiting shackle **104** before the fingers **124** release the chicken **100**. In the shackling operation, the grasper **118** constrains the chicken **100** and the chicken's legs are extended so the shackle **104** can secure the chicken's legs. The automatic transfer system described here does not require the chicken **100** to stand on its own will. Instead, it includes the rotating grasper fingers **124** to support the chicken **100** and uses a pre-determined body-to-feet differential speed to present both legs of the chicken **100** to the shackle **104**.

Prior to entering the grasper **118**, the chickens **100** may be held in a buffer on the conveyor. The buffer timing may be controlled by the system controller of FIG. **9**.

Once the shackle **104** grips the chicken's legs, the chicken **100** and the shackle **104** are moved as a bird/shackle combination **128** towards the end of the conveyor **102**. As shown in appendix G of U.S. Pat. No. 6,623,346, Principles of Operation, subsection "Forward Kinematics," the motion of the chicken's legs can be analyzed and predicted by appropriately controlling the velocities of the conveyor **102** and the rotating grasper cylinders **126**. Appendix G, of U.S. Pat. No. 6,623,346, subsection "Inverse Kinematics," also shows the method to determine the rotating speed of the cylinders of the singulator **108** and the grasper **118** for a given conveyor speed, relative inclination of the rotating axis with respect to the conveyor **102** surface, and the chicken **100** size and entering pose. These calculated parameters will vary depending upon the environmental conditions and the variability in batches of live objects.

The variability within a particular batch can be calculated and used to control the automated system by use of an imaging system including a camera **130**. To account for the varying sizes and entering posture, a digital (line or area) camera **130** with a collocated blue light source **402** (see FIG. **7**A) (or light with blue filter) can be placed before the entrance of the grasper **118**, preferably before the grasper cylinder **126** to obtain a silhouette of the chicken **100** against a retroreflective surface **404** background (such as a 3M Scotchite 580 Black). From the silhouette, the size and the posture (the orientation of the major axis of the chicken **100**), and the leg posture can be computed. Typically, the chickens **100** are placed in a dark room (or room illumination with dim blue light) to calm the chickens **102**. The combined retro-reflective background and the collocated blue filtered light source **402** reduce the computational load of the image processing. The ceiling **116** is made transparent where necessary for the operation of the camera **130**. Once the chicken **100** orientation (forward or backward) and leg posture (joint angles) is computed, the operating speed can be determined in order to manipulate the legs of the chicken **100** using the equations given in the appendix G of U.S. Pat. No. 6,623,346, subsection "Inverse Kinematics," to re-adjust the rotational speed and compensate for the size/pose variation in real-time.

The weight of the bird/shackle combination **128** causes the bird/shackle combination **128** to topple and thus inverts the bird/shackle combination **128**. The shackle **104** with the hanging chicken **100** is then transferred to the moving shackle line **106** which may be a buffer line or may be a kill line.

As shown in FIG. **1**, in the preferred embodiment, the conveyor **102** declines slightly from the singulator **108** to the grasper **118**. The conveyor is designed to incline downward so that the grasper fingers **124** grasp the chicken **100** by its body but allow the legs to extend freely between the hip joints and the feet on the conveyor **102** surface. The inclined surface further encourages the chicken **100** to sit since the bird's natural reflexes to moving on an inclined plane is to lower its center of gravity (CG) in order to maintain its balance.

For high-speed transferring operation, it is desired that the variation of the (initial) birds' posture as they enter the grasper **118** be minimized. Since most chicken's arriving at the system tend to sit (particularly in a relatively dark environment), the "sitting" posture is chosen as a nominal entry posture in the design and control of the automated transfer system. The system includes a ceiling **116** and clear walls **119** that cover and close the sides, respectively, of the conveyor **102**. The ceiling may also extend to reach partially into or over the grasper **118**. The walls **119** and ceiling **116** are clear to allow visibility, to allow for identifying carcasses, and to allow CDC imaging with the LED **122** and orientation imaging with the camera **130**. The system for transferring live objects to a shackle line also includes a recycle conveyor **132** for transporting any escaping chickens back to the singulator **108** area.

FIG. **1**B is a side view of a second embodiment of the system for transferring live objects to a shackle line including a relatively flat conveyor. The components of the second embodiment are similar to the components of the preferred embodiment other than the conveyor **102***b* that is relatively flat.

FIG. **1**C is a third embodiment of the system for transferring live objects to a shackle line including a conveyor with a relatively flat portion and a declined portion. The components of the third embodiment are similar to the components of the preferred embodiment other than the conveyor **103***c* that has a relatively flat portion **134** and a declined portion **136**.

FIG. **2** is a top view of the singulating system **200** for transferring live objects to a shackle line of FIGS. **1**A–**1**C. The singulating system **200** is shown as a dual line system but may be a single line system for the present invention. The singulating system includes a singulating conveyor **202** and a singulator **108** for two lines showing the use of two singulating cylinders **110** for each line of the singulating system.

FIG. **3** is side view of one of the pallets **114** that are attached to the conveyor of the system for transferring live objects to a shackle line of FIGS. **1**A–**1**C. The chicken **100** is dropped from the singulator **108** into the pallet **114**. The pallet **114** includes a pair of latch-able panels (front **302** and back **304**) to restrain the chicken **100** from walking on the conveyor **102**. Immediately after the chicken **100** is dropped into the pallet **114**, the rear panel **304** of the pallet **114** is lowered. The chicken **100** will generally try to balance itself by lowering its center of gravity. After the chicken **100** enters the pallet **114**, the rear panel **304** is raised. The panels **302** and **304** are unlatched and flattened before entering the grasper **118**, and thus minimizing the visual response of the chicken **100** to the revolving fingers **112** of the grasper **118**. The panels **302** and **304** return to the original positions by gravity. The panels may be raised and lowered by pins **306**.

The pallets **114** rotate with the bird/shackle combination **128** at the end of the conveyor **102**. Rotating the pallets with the bird shackle combination **128** prevents any escaping chickens **100** from being trapped between the conveyor **102** and the shackle **104**, thus, allowing the escaping chicken **100** to be dropped on the recycling conveyor **132** unhurt. Since the pallet **114** is rotated with the chicken **100**, the chicken's resistance by gripping on the floor of the pallet **114** has no effect on the inverting process. And, since the time required to invert the chicken **100** depends only on the rotational speed, it significantly minimizes the chicken's **100** struggle.

As compared to the conveyor **102**, individual pallets **114** also offer an advantage for controlling the leg kinematics of the chicken **100**. The chicken **100** is sensitive to the declination of the conveyor **102** surface. The portion of the conveyor **102** surface, where the incoming chickens **100** are on the queue, is kept constant in order to minimize the chicken's **100** natural reflexes. The degree that the rotating axes of the grasper cylinder **126** can be tilted is limited since the grasper fingers **124** would interfere with the declined conveyor **102**.

On the other hand, individual pallets **114** are short and can travel on a much steeper inclined track below the grasper fingers **124**. In addition, the conveyor **102** is designed such that as the chicken **100** is grasped at a constant height, the pallet **114** is lowered, where the legs are inserted to the shackle **104**, then the conveyor **102** is tilted as the pallet **114** and shackled chicken **100** are moving forward, and finally the bird/shackle combination **128** is inverted, and the bird/shackle combination **128** is separated from the pallet **114**. Thus, the use of the pallet **114** provides a more effective means to insert the leg into the shackle **104** before inverting the chicken **100**.

FIG. **4** is a diagram showing the lifting of a live object and the securing of the legs of the live object with a shackle that is a part of the system for transferring live objects to a shackle line of FIGS. **1A**–**1C**. FIG. **4** shows the surface of the conveyor **102**, the shackle **104**, and the chicken **100** to be shackled. FIG. **4** shows the chicken **100** as the chicken **100** is passing through the grasper **118**. For any particular conveyor **102** slope and speed, the velocity of the chicken's **100** body must be lifted over the shackle **104** and the shackle **104** must grip the legs of the chicken **100**.

FIG. **5**A. is a perspective view of the shackle **104** for securing the legs of the chicken **100** shown in FIG. **4**. The shackle includes a gripping area **502** for securing the legs of the chicken **100** when the bird/shackle combination **128** is inverted and a shackle support **506**.

FIG. **5**A shows a compliant shackle, which is designed to adapt non-symmetric insertion of the legs. By allowing the spacing between the two gripping areas **502** to slide freely, the shackle provides negligible resistance along the Ys direction but provides a relatively high stiffness in the Xs direction. Thus, the design allows the legs of different spacing as well as different arrival timing to be inserted before moving them along the Xs direction.

FIGS. **5**B and **5**C show perspective views of the shackle **104** and the shackle support **504** awaiting the arrival of a chicken, FIG. **5**B, and the rotated shackle **104** and shackle support **504** in the position the shackle is as the bird/shackle combination **128** is inverted.

FIG. **6** is a side view of the system for synchronizing the inversion of the shackle **104**, the chicken **100**, and the pallet **114**. FIG. **6** shows a shackle **104** entering the at the top right, a first slider **602** that positions an empty shackle **104** by the shackle support **506** such that it provides a restoring force when the legs of the chicken **100** are engaged in the shackle **104**. The bird/shackle combination **128** travels towards the end of the conveyor **102**, where the second slider **604** engages the pallet **114**. As the relative angular positions of the two sliders **602** and **604** are fixed, the pallet **114** and the bird/shackle combination **128** are synchronized to rotate together. Once the bird/shackle combination **128** rotates, the pallet **114** is separated from the bird/shackle combination **128**. A servomotor (not shown) controls the shackle **104** motion and synchronizes the rotational motion of the pallet **114**, shackle **104**, and the bird/shackle combination **128**. Once the grasper **118** engages the legs, the servomotor behaves as a rotational spring, and exerts a restoring force such that the legs of the chicken **100** are driven further into the shackle **104**, while allowing the bird/shackle combination **128** to travel together.

The cam motion of the shackle **104** is designed such that: The conveyor feeds the legs of the chicken **100** to the gripping area **502** of the shackle **104** while the rotating fingers **124** push the bird out of the grasper **118**; Once the legs are gripped, both the bird and the shackle are pushed together towards the end of the conveyor **102**; At the end of the conveyor, the shackle/bird combination rotates under its own weight (or with additional counter-weight) along with the momentum contributed by the fingers and the conveyor; and once the broiler is inverted, the bird/shackle combination is available for transferring to a moving processing line.

There are several designs that could accomplish the above motion such as, the use of a mechanical spring **508** as illustrated in the figures; the use of a spring-loaded ball plunger so that the fingers/conveyor combination pushes the bird's feet to unlatch the plunger; and the use of a computer-controlled electromechanical linear motor position servo to drive the shackle mechanism.

A typical example position servo configuration is a P01-23×160/200×340 that includes position feedback and its associated power driver, control interface, and software manufactured by LinMot. The active shackle mechanism provides a flexible means to position the shackle using the spring-loaded ball plunger or to modify the stiffness using the mechanical spring **508**. An alternative means to achieve the shackle motion control is to use a position-feedback cylinder, and its associated control valve and interface with the computer manufactured by Bimba Manufacturing Co. Yet another alternative means of achieving computer-control is to use a computer-controlled rotary motor with a reciprocating mechanism such as an Uhing Linear Drive Nut manufactured by Amacoil, Inc.

FIG. **7**A shows an imaging system for determining the orientation of the live objects of the system for transferring live objects to a shackle line of FIGS. **1A**–**1C**. The imaging system includes a camera **130**, a light source **402**, and a retro-reflective surface **404**.

FIGS. **7**B and **7**C show a block and a node diagram of a neural network that shows one system for controlling the operation of the system for transferring live objects to a shackle line of FIGS. **1A**–**1C**. An alternative method to determine the grasper cylinder **126** speed to compensate for the size and posture variation of the chickens **100** is to use a trained neural network algorithm with the following input-output training pairs, which could be prepared experimentally:

5 Inputs=[w; h, β; $\phi_1(t_f)$, $\phi_2(t_f)$]; 1 Output=ω

where h and β describe the height of the geometrical center and the orientation of the silhouette of the incoming bird. These parameters, which characterize the posture of the incoming bird, can be obtained using a digital camera **130** with image processing software. With the input-output pairs, the network can be obtained using Levenberg-Marquardt learning method (see, for example, the MATLAB Neural Net Toolbox Manual). Once the network is trained, it can be used to determine the drum speed needed for a particular set of inputs. A sample program, such as the one below can be used to obtain the leg posture from the chicken silhouette obtained from the digital camera.

Sample Program

```
range=[min(inputs)‘ max(inputs)’];
rand(‘state’,0);
num_vals=length(inputs);
index=randperm(num_vals);

% Split the Training Data Set into Training and Validation Sets
train13 in=inputs(index(1:floor(num_vals/2)),:)’;
train_out=outputs(index(1:floor(num_vals/2)))’;
validate.P=inputs(index(ceil(num_vals/2):num_vals),:)’;
validate.T=outputs(index(ceil(num_vals/2):num_vals))’;

% Form the Initial Network and Set Parameters
legnet=newff(range,[5 1],{‘tansig’ ‘purelin’ });
legnet.trainParam.epochs=50;
legnet.trainParam.show=[ ];

% Train Using Default Levenberg-Marquardt Method

% See the NNET Toolbox Manual.
[legnet,legperf]=
train(legnet,train_in,train_out,[ ],[ ],validate);
figure (2),clf
semilogy(legperf.epoch',legperf.perf',legperf.epoch',
   legperf .vperf', ‘--’)
xlabel(‘Epoch Number’),ylabel(‘Mean Squared Error’);
title_s=sprintf(‘Leg-motion NN Performance (Min training
   MSE=% g)’, . . .
   min(legperf.perf));
title(title_s),legend(‘Training’,‘Validation’,0);
```

The above algorithm can be used to obtain the leg posture from the bird silhouette obtained digitally with

3 Inputs=[w; h, β;};2 Outputs=[$\phi_1(t_f)$, $\phi_2(t_f)$]

which can be used with the inverse kinematics to determine the operating speeds.

FIGS. **8**A–**8**C are sample plots for use in controlling the system for transferring live objects to the shackle line **106** of FIGS. **1**A–**1**C through the use of the neural network of FIGS. **7**B and **7**C.

FIG. **9** is a block diagram of a system operation control sequence for controlling the operation of the system for transferring live objects to a shackle line of FIGS. **1**A–**1**C.

The operations of the system are controlled by a system controller **902**. The system controller coordinates the following sequential tasks:

1. Continuous control of the conveyor **102** speed by a digital PID controller.

1a: voltage command;

1b: tachometer feedback

2. The beam-switch **133** signals the arrival of a chicken **100**.

3. The imaging sensing and control algorithm

3a: triggers the imaging sensor **135** to capture an image of an incoming bird through the camera **130**

3b. store and process image. The initial posture of the chicken **100** is computed.

3c: compute the desired grasper cylinder **126** speed profile

3d: compute the desired shackle **104** position

4. Control the grasper cylinder **126** speed by a digital PID regulator with a tracking controller.

4a: voltage command;

4b: tachometer feedback

5. Control the desired position by a digital PID controller.

5a: voltage command;

5b: position and force feedback

6. Signal the completion of the cycle.

Appendices A–J of U.S. Pat. No. 6,623,346 provide analytical models, design calculations, system criteria, kinematic simulation analysis, imaging system analysis, principles of operation, modeling, motion prediction analysis, and design algorithm related to the automated transfer of live objects apparatus and method. Appendices A–J of U.S. Pat. No. 6,623,346 are incorporated herein in their entirety by reference.

The neural network of the present invention can be implemented in hardware, software, firmware, or a combination thereof. In the preferred embodiment(s), the neural network is implemented in software or firmware that is stored in a memory and that is executed by a suitable instruction execution system. If implemented in hardware, as in an alternative embodiment, the neural network can implemented with any or a combination of the following technologies, which are all well known in the art: a discrete logic circuit(s) having logic gates for implementing logic functions upon data signals, an application specific integrated circuit (ASIC) having appropriate combinational logic gates, a programmable gate array(s) (PGA), a field programmable gate array (FPGA), etc.

FIG. **10** is a plan view depicting a system **1000** for a automated feet-gripping system in accordance with a preferred embodiment of the invention. The system **1000** includes a conveyor **1002**, such as motorized chain, an example of an automated feet-gripping system **1004**, a grasper system **1006** and a shackle control mechanism **1007**. The system **1000** provides for a mechanical inversion of the live objects when the live objects reach an end of the conveyor and continue to rotate and travel along an underside of the conveyor **1002**.

FIG. **11** is a schematic diagram of a motorized chain conveyor **1002** in accordance with a preferred embodiment of an automated feet-gripping system. The conveyor **1002** includes a chain **1108**, a plurality of tracks **1110**, **1112**, a drop cam **1114**, a servomotor **1116**, an inversion path **1118**, and a shackle control mechanism **1007** (FIG. **10**). A plurality of trolleys (only one shown for simplicity) **1120** is movably affixed to the conveyor **1002**. The trolley **1120** includes rollers **1122** for traversing along the track **1112** in a x-direction. The x-direction, as referred to in this disclosure, is the direction of travel of the conveyor **1002**. Hence, if a live object is facing in the direction of the conveyor **1002**, then the x-direction refers to the anterior-posterior axis of the live object **100**. Similarly, the z-direction, as referred to in this disclosure, refers to the superior-inferior axis of the live object **100** when the live object is positioned upright on the conveyor **1002**. Likewise, for live objects positioned upright on the conveyor **1002** and facing the direction of travel of the conveyor **1002**, the y-axis refers to the lateral axis of the live object **100**.

Since the conveyor **1002** is configured to transport live objects, it is desirable to manage the timing of each sequence such that there is minimal disruption in the transport of the live object. In this regard, some embodiments of the process begin when the pallet assembly **1204** (FIG. **12**) reaches a magnetic sensor **1102** and triggers the magnetic sensor **1102**. The triggering of the magnetic sensor **1102** provides a landmark time for the beginning of the process. Upon triggering the magnetic sensor **1102** (labeled (a) in FIG. **11**), the pallet assembly **1204** travels along the conveyor **1002** (labeled (b) in FIG. **11**) until the pallet assembly **1204** reaches the top of the drop cam **1114**. As the live objects arrive at the top of the drop cam **1114** (labeled (c) in FIG. **11**), the live objects are secured by fingers **1706** on a pair of rotating hands **1702**, and moved forward in the x-direction by the rotating hands **1702**. The rotating hands **1702** and the fingers **1706** are shown in greater detail with reference to FIGS. **17**, **18**, and **19** below.

As the live objects travel forward (x-direction) and downward (negative z-direction) along the drop cam **1114** (between (c) and (d) in FIG. **11**), the legs of the live object are inserted into a shackle assembly **1302** and locked into the shackle assembly **1302** by a trap bar **1410**. The shackle assembly **1302** and trap bar **1410**, along with their operation, are shown in greater detail with reference to FIGS. **13**A through **13**E, FIGS. **14**A through **14**H, and FIG. **15** below.

Upon reaching the bottom of the drop cam **1114** (labeled (d) in FIG. **11**), the live objects are ejected from the rotating hands **1702** along the inversion path **1118**, which inverts the live objects. Being inverted, the live objects travel between the inversion path **1118** and a release point (labeled (e) in FIG. **11**), where a quick-release mechanism releases the live objects. As shown in this embodiment, each step of the process is timed to provide a smooth operation of the entire system **1000**.

FIG. **12** is a schematic diagram of a motorized chain conveyor **1002** having a plurality of automated feet-gripping system(s) **1004** thereon in accordance with a preferred embodiment of the invention. In a preferred embodiment, the automated feet-gripping system **1004** includes the trolley **1120** that traverses along tracks **1112** of the conveyor **1002** in the x-direction (anterior-posterior axis). The automated feet-gripping system **1004** includes a pallet assembly **1204**. The pallet assembly **1204** includes rollers **1206** that run along the track **1110**. Upon encountering the drop cam **1114**, rollers **1122** of the trolley **1120** continue to traverse in an x-direction while the rollers **1206** of the pallet assembly **1204** follow the drop cam profile causing the surface of a pallet **1208** to lower. The operation of the trolley **1120** and its related components is shown in FIGS. **13**A through **15**. In a preferred embodiment, a body of the live object **100** is supported by the grasper system **1006**, as shown in FIG. **17**, and thus the feet of the live object **100** are extended in a substantially vertical direction (i.e., z-direction or superior-inferior axis of the live object).

FIGS. **13**A through **13**E are schematic diagrams of an illustrative example of degrees of movement of an automated feet-gripping system **1004** in accordance with a preferred embodiment of the invention. In an example, the trolley **1120** traverses along the track **1112** in a x-direction. The pallet assembly **1204** traverses along the track **1110** in a x-direction and can also move in a z-direction. A shackle assembly **1302** of the automated feet-gripping system **1004** is movably affixed to the pallet assembly **1204** and travels in a x-direction and has flexibility to move in a z-direction. The trolley **1120** and pallet assembly **1204** travel together on two separate tracks of the conveyor **1002** such that the pallet assembly **1204** travels with the trolley in the x-direction but is free to slide vertically relative to the trolley along the z-direction. When the trolley **1120** encounters the drop cam **1114**, the pallet assembly **1204** follows the drop cam profile and the pallet z-translational guide **1304** provides for the pallet assembly **1204** having movement in the z-direction along the lowered track **1110** while the trolley **1120** continues to travel in a x-direction.

Graphically illustrated, FIGS. **13**B through **13**E show an embodiment of the operation of the feet-gripping system **1004**. As shown in FIG. **13**B, the trolley **1120** moves in the x-direction according to the arrow (r). Upon reaching the top of the drop cam **1114**, a motion control rod **1420**, which is a part of the shackle assembly **1302**, contacts a shackle stopper **1504** at point (s). Hence, when the trolley **1120** reaches the top of the drop cam **1114**, the trolley **1120** continues to move in the x-direction while the shackle assembly **1302** stops due to the shackle stopper **1504**.

Continuing in FIG. **13**C, the trolley **1120** continues in the x-direction (shown as (t") in FIG. **13**C) and, consequently, also drops in the negative z-direction (shown as (t') in FIG. **13**C), thereby resulting in a downward diagonal travel (shown as (t) in FIG. **13**C). Meanwhile, the shackle assembly **1302** remains stationary due to the impediment provided by the shackle stopper **1504**. Hence, from the framework of the trolley **1120**, the shackle assembly **1302** travels in the direction of the arrow (u). The relative movement between the trolley **1120** and the shackle assembly **1302** brings a trap bar **1410** in closer proximity to the shackle assembly **1302**.

Continuing in FIG. **13**D, once the trolley **1120** reaches the bottom of the drop cam **1114**, a portion of the trolley **1120** engages the trap bar **1410** in a trap bar assembly **1402** at point (w). Since the trap bar assembly **1402** is pivotally connected to a trap bar cam, the engaging of the trap bar **1410** with the trolley **1120** results in a pivotal rotation of the trap bar **1410** in the direction of the arrow (x). As a result of the pivotal rotation, the trap bar **1410** engages the shackle assembly at point (y) as shown in FIG. **13**E.

Continuing in FIG. **13**E, as the trolley **1120** continues to move forward in the x-direction, the legs of the live object are now secured in the shackle assembly **1302** by the trap bar **1410**. The trap bar **1410** is maintained in the secured position by magnetic forces, as described below with reference to FIGS. **14**A through **14**H. As shown in FIG. **13**E, as the trolley **1120** progresses in the x-direction, the trolley **1120** engages the shackle releaser **1506** at point (z). The engaging of the shackle releaser **1506** by the trolley **1120** results in a removal of the previously-existing impediment in the x-direction, thereby releasing the shackle assembly **1302** and the pallet assembly **1204** for further movement in the x-direction. Details related to the releasing of the shackle assembly **1302** are provided with reference to FIG. **15**.

As shown from FIGS. **13**A through **13**E, several mechanical forces are applied to the various components of the shackle assembly **1302**, the pallet assembly **1204**, and the trap bar assembly **1402**, thereby providing a relatively-seamless approach to securing a live object as the live object is being transported along the conveyor **1002**. The various points in the process are also highlighted in the graph of FIG. **20**. Specifically, FIG. **13**B corresponds to time point T1 in FIG. **20**; FIG. **13**C corresponds to T3 of FIG. **20**; FIG. **13**D corresponds to T4 of FIG. **20**; and FIG. **13**E corresponds to

T5 of FIG. **20**. FIGS. **14**A through **19** provide greater details related to the components described above.

FIG. **14**A is an exploded schematic diagram of an automated feet-gripping system in accordance with a preferred embodiment of the invention. In an example, the automated feet-gripping system **1004** includes a pallet assembly **1204**, a shackle assembly **1302**, a trolley **1120**, a trap bar assembly **1402** and a shackle lock and release mechanism **1404**.

In a preferred embodiment, the pallet assembly **1204** includes a perch bar assembly **1405** having a perch bar **1406**, a release pin for the shackle stopper **1407**, a back panel **1408**, pallet z-translational guide **1304**, rollers **1206**. The trap bar assembly **1402** includes a bar **1410** that rotates along a rotating axis, a roller **1409** and cam profile **1411** and a magnetic lock **1421**.

In a preferred embodiment, the trap bar assembly **1402** provides for rotating the hocks of the live objects about its toe joints so that the shackle grips the feet below the hocks. Further, the trap bar assembly **1402** locks both feet of the live object in the pair of grippers. Still further, once the live object is inverted, the trap bar assembly **1402** serves as a part of the shackle structure that supports the weight of the inverted live object. The trap bar assembly **1402** has rotational freedom about a rotating axis fixed with respect to the pallet **1208**. The rotation of the trap bar assembly **1402** is driven by the trap bar cam profile **1411** acting on a roller **1409** that moves with the shackle assembly **1302** in the x-direction. The bar **1410** can be maintained at a final position by magnetic attraction applied between the trap bar assembly and the pallet assembly **1204**.

In a preferred embodiment, the shackle lock and release mechanism **1404** includes a x-motion lock mechanism **1415** and a spring **1417** for quick release of the shackle **1413**. In an example, the shackle lock and release mechanism **1404** provides for controlling the shackle motion in the x-direction. Preferably, the x-motion lock mechanism **1415** includes two mechanical levers with a spring and a latch. The rotational axes of the mechanical levers are preferably fixed on the shackle assembly **1302**, for example on the trap bar cam profile **1411**, such that the x-motion lock mechanism **1415** moves with the shackle **1413** in the x-direction. The quick release spring keeps a space between the shackle **1413** and the pallet **1208** normally open. When the rollers **1206** of the pallet assembly **1204** reach the end of the drop cam profile **1114**, the space between the shackle **1413** and the pallet **1208** closes. At that instant, the jaws of the x-motion lock mechanism **1415** snap the latch, which is fixed relative to the pallet **1208**. The shackle **1413** and the pallet **1208** remain locked until they reach a point under the conveyor **1002** where the transferring of the live object **100** to a kill-line shackle takes place.

In a preferred embodiment, the shackle assembly **1302** includes a x-motion guide **1412** and z-motion guide rods **1418**, and a motion control rod **1420** which can be locked together by means of magnetic attraction. In an example, the x-motion guide provides a base for mounting the trap bar cam profile **1411**, magnetic locks **1416**, and linear bearings to guide the shackle motion in the z-direction. Preferably, the shackle assembly **1302** includes a compliant shackle **1413** having a pair of feet grippers **1419**. In a preferred embodiment, the grippers **1419** are compliant laterally but rigid in the direction perpendicular to the shackle plane in order to support the weight of an inverted live object. The shackle **1413** and grippers **1419** are preferably configured as a rigid rod constructed of for example sheet stainless steel and covered with a material such as synthetic rubber for frictional gripping. The synthetic rubber covering has a high coefficient of friction for gripping and serves as a compliant media to protect and accommodate a relatively wide range of bird feet sizes.

In an example, grippers **1419** and a shackle motion control rod **1420** are movably affixed to the z-motion guide rods **1418**. Preferably, the shackle control rod **1420** which is rigidly attached to the compliant shackle **1413**, moves with the pallet **1208** in the x-direction. In a preferred embodiment, the z-motion of the shackle control rod **1420** is gravity actuated.

FIG. **14**B is an exploded view of the trap bar assembly **1402** of FIG. **14**A. As shown in FIG. **14**B, the trap bar assembly **1402** includes a trap bar cam **1411**, a roller **1409**, and a magnetic lock **1421**. As described with reference to FIGS. **13**A through **13**E, the trap bar **1410** pivots about a rotational axis due to contact between the trap bar assembly **1402** and the trolley **1120**. Specifically, the trolley **1120** makes contact with the roller **1409** at point (w) of FIG. **13**D. The magnetic lock **1421** is responsible for maintaining the locked position ((y) of FIG. **13**E) once the trap bar **1410** engages the shackle assembly **1302**.

FIGS. **14**C through **14**H are diagrams illustrating, in greater detail, the shackle locking and release mechanism **1404** of FIG. **14**A. As shown in FIG. **14**C, the motion control rod **1420** approaches a x-locking mechanism **1415** as shown by arrows (f). As described below, the x-locking mechanism **1415** engages a corresponding set of teeth, thereby providing a secure lock between the x-locking mechanism **1415** and the teeth. FIGS. **14**D through **14**H show the locking and releasing mechanism in greater detail.

As shown in FIG. **14**D, the x-locking mechanism **1415** includes a set of magnets **1434** and a set of clasps **1432**. The set of clasps **1432** are configured to open and close, thereby selectively engage or disengage a set of teeth **1452**. The set of magnets **1434** are arranged such that the polarity of the magnets opposes a complementary set of magnets **1454** coupled to the teeth **1452**. The teeth **1452** are also coupled to a set of springs **1456** located on the motion control rod **1420**. The springs **1456** provide compliance in the x-direction, thereby permitting the shackling of live objects having different physical dimensions.

In operation, the x-locking mechanism **1415** travels toward the teeth **1452** on the motion control rod **1420**, as shown by the arrow (f). Due to the structure of the clasps **1432** and the teeth **1452**, the x-locking mechanism **1415** opens as the clasps **1432** engage the teeth **1452**. Once the clasps **1432** have traveled past the teeth **1452**, the clasps **1432** close to securely grasp the teeth **1452**. The clasps **1432** and the teeth **1452** engage each other as shown by the arrows (g), thereby resulting in an assembly as shown in FIG. **14**E.

As shown in FIG. **14**E, the teeth **1452** and the clasps **1432** are engaged at point (h). The closing of the clasps **1432** is regulated by the force of a spring **1496**, which applies a force to the x-locking mechanism **1415** to close the clasps **1432** around the teeth **1452**. The engaging of the teeth **1452** with the clasps **1432** brings the magnets **1434** and **1454** in close proximity to each other. The polarities of the magnets are arranged such that, when the clasps **1432** are securely engaged with the teeth **1452**, an attractive force **1458** is present between the sets of magnets **1434** and **1454**.

The attractive force **1458** results in further travel of the x-locking mechanism **1415** in the x-direction, as shown in FIG. **14**F. Hence, the x-locking mechanism **1415** applies a force on the teeth assembly, thereby compressing the springs **1456**. The compression of the springs **1456** and the attraction of the magnets **1434**, **1454** results in a compliance in the x-direction, thereby permitting the shackling of live objects having different size legs.

FIGS. **14**G and **14**H are diagrams illustrating a quick release of the teeth **1452** from the clasps **1432**. As shown in FIG. **14**G, the x-locking mechanism **1415** is pivotally secured to the shackle lock-and-release assembly **1404**. Thus, when one end of the x-locking mechanism **1415** opens, the opposing end of the x-locking mechanism **1415** closes. Similarly, when one end of the x-locking mechanism **1415** closes, the opposing end opens. When the clasps **1432** open according to the arrows (i), the polarities of the magnets **1434**, **1454** produce a repulsive force **1472**. The repulsive force **1472** results in a quick release of the x-locking mechanism **1415** from the motion control rod **1420**, as shown by the arrow (j). In addition to the repulsive force **1472**, for some embodiments, a spring mechanism **1417**, as shown in FIG. **14**D, further assists to disengage the x-locking mechanism **1415** from the motion control rod **1420**. Upon release, the live object may be transported by other means not described herein.

Since the timing of the shackling and releasing contributes to the smooth operation of the system **1000**, it is desirable to have the release mechanism be quick and reliable. By providing both a magnetic release mechanism and a spring release mechanism, as shown in FIGS. **14**A through **14**G, a minimal disruption is produced in the system **1000**.

FIG. **14**H is a diagram showing an embodiment of a system for opening and closing the clasps **1432**. As shown in FIG. **14**H, some embodiments of the x-locking mechanism **1415** include multiple pivoting legs, which are coupled to each other, thereby effecting a lever movement about several pivot points. A first set of legs (referred to as "upper legs") includes the clasps **1432**, which open in the direction shown by arrows (i). The upper legs are secured to upper pivot points **1490**, thereby permitting a rotational motion about the pivot points **1490** as the clasps **1432** open and close. The opening of the clasps **1432** according to (i) results in the closing of the legs at the opposing end (n) due to the pivoting motion of the upper legs.

If the upper legs are secured to another set of legs (referred to as "lower legs"), at point (n), then, at the point of contact (n), the movement of the lower legs will mimic the movement of the upper legs. In other words, if the upper legs open at (n), then the lower legs will open at (n). Conversely, if the upper legs close at (n), then the lower legs will close at (n). If the lower legs are secured to pivot points **1486**, then the lower legs will pivot in a manner similar to the upper legs. In other words, as the secured end of the lower legs closes as shown by arrows (n), the non-secured end **1480** of the lower legs will open as shown by arrows (m).

As will be appreciated by those of skill in the art, the mechanical coupling **1488** of the upper legs and the lower legs results in a dependent motion of the upper legs and the lower legs. In other words, when the lower legs open and close, the upper legs will open and close in a corresponding manner. Hence, by controlling the opening and closing of the lower legs, one may control the opening and closing of the clasps **1432**.

In some embodiments, the opening and closing of the clasps **1432** is effected by a release cam **1482** that is located at position (e) in FIG. **11**. The release cam **1482** is configured to open the non-secured portion **1480** of the lower legs, thereby effecting the opening of the clasps **1432**. Thus, as the release cam **1482** approaches the shackle lock-and-release assembly **1404**, when the release cam **1482** engages the non-secured portion **1480**, the release cam **1482** opens the non-secured portion **1480** by applying a lateral mechanical force to the non-secured portion **1480**. As the non-secured portion **1480** opens, the clasps **1432** open in a corresponding manner.

As described with reference to FIG. **14**G, the opening of the clasps **1432** positions the magnets such that a repulsive force is produced between the magnets. The repulsive force acts to quickly disengage the shackle lock-and-release mechanism **1404**, as described above.

FIG. **15** is a schematic diagram of a shackle control mechanism **1007** in accordance with a preferred embodiment of the invention. The shackle control mechanism **1007** includes a shackle stopper **1504** and a shackle releaser **1506**. The shackle control mechanism **1007** provides for mechanically controlling the motion of the shackle during the drop cam motion of the pallet assembly **1204** on the conveyor **1002** by interaction among the shackle control rod **1420**, shackle stopper **1504**, shackle releaser **1506**, and the release pin **1407** for the shackle stopper. In an example, the shackle control mechanism **1007** provides a two stage stop or move control action in both x and z-directions. Preferably, the shackle control mechanism **1007** is mounted on a fixed structure such as the conveyor shown in FIG. **10**, which limits the motions of the shackle control rod **1420** in both x and z-directions. In an example, the motion limit of the pallet assembly **1204** is removed by the release pin **1407** which moves with the x-motion of the pallet assembly **1204** or trolley **1120**.

Specifically, the operation of the shackle-control mechanism begins with both the shackle stopper **1504** and the shackle releaser **1506** engaged at a contact point **1505**. The shackle stopper **1504** is maintained in an upright position by a release spring **1508**. Hence, in the absence of other forces, the release spring **1508** applies a force to the shackle stopper **1504**, thereby preventing the shackle stopper **1504** from pivoting on its own. As described with reference to FIG. **13**E, as the trolley **1120** moves in the x-direction shown by arrow (o), the trolley **1120** makes contact with the shackle releaser **1506** at point (z). When the trolley **1120** moves further along (o), the shackle releaser **1506** pivots in the direction shown by arrow (p). The pivoting of the shackle releaser **1506** results in a disengaging of the shackle releaser **1506** from the shackle stopper **1504**. Once the shackle releaser **1506** and the shackle stopper **1504** have been disengaged, the shackle stopper **1504** is free to pivot in the direction shown by arrow (q) when a force is applied to the shackle stopper **1504** in the x-direction. The pivoting of the shackle stopper **1504** according to (q) releases the trolley **1120** to travel along the conveyer **1002** to the inversion path **1118**.

FIG. **16** is a schematic diagram of a perch bar of an automated feet-gripping system in accordance with a preferred embodiment of the invention. In an example, the perch bar **1406** is preferably configured as a rigid rod **1602** that can be constructed from a plurality of materials such as sheet stainless steel. In an example, the rigid rod **1602** is I-shaped on the distal ends, with a center portion **1607** having a length greater than the distal ends. The perch bar **1406** includes cylindrical rods **1604**, **1606** movably affixed to the center portion **1607** of the rigid rod **1602**. In an example, the cylindrical rods **1604**, **1606** include a plurality of grooves **1608**. Preferably, the cylindrical rods **1604**, **1606** and grooves **1608** are covered with a material such as synthetic rubber for frictional gripping. The synthetic rubber covering has a high coefficient of friction for perching and serves as a compliant media to protect and accommodate a relatively wide range of bird feet sizes. In a preferred embodiment, the center portion **1607** of the rigid rod **1602** is also covered by the synthetic rubber material.

The pliability of the synthetic rubber permits slight movements in the z-direction (superior-inferior axis of the live object). The pliability in the z-direction permits the system **1000** to handle live objects of various sizes. As described above, the compliance in the x-direction, which is provided by the springs **1456** on the motion control rod **1420**, in addition to the compliance in the z-direction provide greater flexibility in handling live objects of various sizes. Also, as describe above, the lateral compliance of the grippers **1419** provides even greater flexibility. In other words, by providing compliance in the x-, y-, and z-directions, flexibility is provided to shackle legs of live objects of various sizes.

FIG. **17** is a schematic view of an illustrative embodiment of a grasper system **1006** of an automated feet-gripping system in accordance with a preferred embodiment of the invention. The grasper system **1006** includes a pair of rotating hands **1702**. The grasping system **1006** preferably also includes spin control for controlling the rotation of the pair of rotating hands **1702** such that the rotation control includes continuous spin, step spin or stop rotation. Each rotating hand **1702** includes a supporting structure **1704** and a plurality of fingers **1706**. The grasping system **1006** is further configured to vary the x-translational speed of the live object **100** while constraining the body in the compliant fingers. In a preferred embodiment, the rotating hands **1702** rotate at the same speed but in opposite directions, which provides for constraining the live object's body while allowing the live object to extend its legs freely. Since the live object tends to keep its feet in contact with the perch bar **1406**, this movement provides for both legs of the live object to be located and inserted into the shackle **1413**.

FIG. **18** is a schematic view of an illustrative embodiment of a supporting structure **1704** of a grasper system **1006** in accordance with a preferred embodiment of the invention. The supporting structure **1704** includes an upper portion **1802**, a lower portion **1804**, and a plurality of apertures **1806**, **1808** disposed in the upper portion **1802** and lower portion **1804**. The supporting structure preferably includes an opening **1810** for receiving a device for connecting to the grasper system **1006**. In a preferred embodiment, the apertures **1806**, **1808** are configured to provide a basic set of five fingers holes **1812**, an additional front finger hole **1814**, an additional back finger hole **1816**, a top front finger hole **1818**, and a top back finger hole **1820**.

FIG. **19** is a schematic view of an illustrative embodiment of a supporting structure **1704** having a plurality of fingers **1706** of a rotating hand **1702** of FIG. **17** in accordance with a preferred embodiment of the invention. In an example, the set of five finger holes **1812** includes a plurality of compliant fingers **1706** of varying lengths. In an example, the complaint fingers **1706** encompass a structural rigidity between 0.08 Nm^2 and 0.35 Nm^2. The set of five fingers **1902** preferably encompasses grasping fingers. In an example, the grasper system **1006** is configured to including a plurality of sets of five fingers **1902**. The set of five fingers **1902**, are preferably organized into two rows in which the lowest row of three fingers supports the weight of the live object and the upper row of two fingers constrain the live object from above. Fingers **1904**, **1906**, referred to as tolerance fingers, on the lower portion **1804** of the supporting structure **1704** are provided to accommodate a larger range of live objects. Fingers **1908**, **1910**, referred to as constraining fingers, on the upper portion **1802** of the supporting structure **1704** are provided to fill a space between an adjacent set of fingers to prevent the live object from escaping upward. In an embodiment, fingers on the upper portion **1802** of the supporting structure **1704** angle upward and fingers on the lower portion **1804** of the supporting structure **1704** angle downward.

FIG. **20** is a graph illustrating an example of timing control in accordance with a preferred embodiment of the invention. The graph **2000** illustrates the control sequence that synchronizes the motions of the shackle and pallet with respect to the rotating fingers as a function of time. Line **2002** represents the perch bar **1406** (in reference to a x axis). Line **2004** represents the pallet **1208**. Line **2006** represents the trap bar **1410** (or back bar) of the pallet assembly (in reference to the x axis). Line **2008** represents a tip of the shackle **1413** (in reference to the x axis). Line **2010** represents the trap bar **1410** (or back bar) of the pallet assembly (in reference to the z axis). Line **2012** represents the tip of the shackle **1413** (in reference to the z axis). Line **2014** represents the perch bar **1406** (in reference to the z axis).

In an example, when the pallet assembly **1204** arrives at the drop cam **1114**, the rotating fingers of the grasper assembly **1006** cradle the live object such that the body translates in a x-direction while the fingers **1706** maintain the body of the live object at a specific height and the feet of the live object follow the perch bar **1406** as it follows the drop cam profile **1114**. FIG. **20** illustrates the timing control that synchronizes the motions of the shackle assembly **1302** and the pallet assembly **1204** with respect to the rotating fingers **1706** in a typical cycle. The XYZ coordinate reference frame (as shown in FIGS. **11** and **12**) is preferably assigned at the interaction between the plane containing the conveyor drum axes and the plane of the shackle assembly, where the z axis points upwards and the x axis points in the direction of the trolley motion.

At point T1, the rollers for the pallet assembly **1204** are at the beginning of the drop-cam profile **1114**. At that instant, the shackle motion control rod **1420** is prevented from moving forward by the shackle stopper **1504** of the shackle control mechanism **1007** but is allowed to lower with the pallet. In an example, the nominal position of the shackle stopper **1504** is held by a counter-clockwise movement offered by an extension spring and a pin fixed with respect to the XYZ frame. To prevent the shackle assembly **1302** from moving forward, the clockwise rotational freedom of the shackle stopper **1504** is rigidly latched by the movement of the counterweight.

At point T2, the pallet motion follows the cam profile **1114**, and the shackle **1413** is lowered with the pallet **1208** to a pre-specified height and held stationary by the shackle stopper **1504**. At this instant, the z-motion of the shackle is magnetically locked. The space between the shackle **1413** and the perch bar **1406** is designed such that the shackle **1413** barely slides over the feet of the live object to ensure consistent shackling at a specified location on the feet.

At point T3, the rollers **1206** of the pallet continue to move forward and lower as it follows the drop cam profile **1114**. Both feet of the live object are driven into the gripping areas of the shackle **1413**, which is held stationary.

At point T4, as the rollers **1206** of the pallet move pass the end of the drop cam profile **1114**, both feet are gripped in the shackle **1413**. The stationary trap-bar cam profile **1411** causes the trap bar **1410** (also referred to as back bar) that moves with the pallet **1208** in the x-direction to rotate the hocks of the live object about its toe joint.

At point T5, the trap bar **1410** rotates the hocks until they are higher than the plane of the shackle **1413** and is then kept at its final position by a pair of magnets that are mounted on the underside of the perch bar. The closing of the trap bar **1410** prevents the live object from retracting one of its legs which is a natural reaction of the live object when it is given time to react. The use of the trap bar provides for the use of short grippers so that the live object can be easily offered from the pallet **1208** to a kill line shackle and provides more consistent shackle of the feet of live objects by lifting the hocks above the shackle **1413**.

At point T6, as the shackled live object continues to move with the trolley, the release pins **1407** fixed on the pallet causes the shackle releaser **1506** to rotate counter-clockwise and thus release the shackle stopper **1504**. Driven by the motorized chain-conveyor, the momentum of the combined pallet-shackle-live object causes the shackle stopper **1504** to rotate clockwise and free the x-motion of the automated feet-gripping system **1004**, which follows the inversion path along which the live object inverts.

FIG. **21** is a graph illustrating an example of a displacement timing diagram in accordance with a preferred embodiment of the invention. The graph **2102** shows a timing diagram illustrating the displacements of the rotating hands **1702** and four sequential pallets **1208** for continuous transfer of live objects **100**. In an example, line **2104** represents the pallet translation displacement and line **2106** represents finger rotational displacement.

In a preferred embodiment, the rotating hands **1702** rotate at a speed ω_a for a specified angular displacement, within which the set of fingers **1902** cradle the live object in order to grip both of its feet. The rotating hands **1702** then rotate at speed ω_b so that another set of fingers are available to cradle a live object that arrives in the next pallet assembly **1204**. In order to match the motion of the rotating hands **1702**, the pallet assembly **1204** moves at a velocity v_1 as the rollers **1206** of the pallet assembly **1204** follow the drop cam profile **1114**, and at v_2 for the remaining spacing between the two adjacent pallets. For example,

$$v_1\Delta t_1+v_2\Delta t_2=D_\rho$$

$$\omega_a\Delta t_a+\omega_b\Delta t_b=\theta_f$$

where $\Delta t_1+\Delta t_2=\Delta t_a+\Delta t_b$;

D_ρ denotes the spacing between two adjacent pallets **1208**; and

θ_f is the angular spacing between two adjacent sets of fingers **1902**.

In an example where $\theta_f=120°$, X_c represents the length of an open pallet (see FIG. **12**), $D_\rho=18$ inches and the length of an opened pallet $(X_c)=12$. When utilizing the above formula and a rotating speed of $\omega_a=20$ rpm, the preferred pallet assembly velocities are $v_1=18$ inches/sec and $v_2=10$ inches/sec. For an average speed of a pallet of 12 inches/sec, ω_b is set to zero for the period equal to 6 inches of distance traveled by the pallet assembly **1204**. Thus, the throughput of the system can be set by appropriately adjusting the speed ratio and the spacing D_ρ.

In an example, the set of fingers **1902** rotates in synchronization with the movement of the pallet assembly **1204** in a x-direction. A speed control module of the grasper system **1006** is utilized to change the speed and to control the timing of rotating fingers **1902** in relation to the movement of the pallet assembly **1204** thereby controlling the production rate of live objects **100** being shackled and pushed through the fingers to the inverted path **1118** of the conveyor **1002**. For example, using a rotating speed $\omega_a=20$ rpm, approximately 60 live objects **100** per minute can be shackled. By reducing or increasing the rotating speed, the production rate can be appropriately changed. Further, controlling the speed of the rotating fingers **1902** is useful in ensuring that the live objects **100** are supported and constrained by the rotating fingers **1902** so shackling of feet can occur and that the live objects **100** are not rushed through the grasper system **1006** without having their feet shackled. Preferably, a set of fingers **1902** supports and constrains a first live object on a pallet **1208**. The live object on the pallet **1208** continues to traverse along the conveyor **1002** to be shackled and then on to the inversion path **1118** of the conveyor **1002**. The supporting structure **1704** rotates to position the next set of fingers **1902** for grasping the next live object **100** traveling on the conveyor **1002** as it enters the grasper system **1006**. The arrival of the next pallet **1208** is detected by a magnetic sensor **1102**. The signal from the magnetic sensor **1102** is used to synchronize the rotation of the fingers **1902** with the movement of the pallet **1208**. That live object is shackled and the process continues. In a preferred embodiment, the speed control module controls the timing of the rotation of the fingers **1902** in relation to the speed of the conveyor **1002** such that the rotation of the fingers **1902** moves the live object **100** from the fingers **1902** at a specified rate. In an example, the fingers **1902** can be rotated approximately 100° to grasp a live object **100** and then further rotated approximately 140° to be in position to grasp the next live object **100** on a pallet **1208** awaiting grasping by the fingers **1902**.

Any process descriptions or blocks in flow charts should be understood as representing modules, segments, or portions of code which include one or more executable instructions for implementing specific logical functions or steps in the process, and alternate implementations are included within the scope of the preferred embodiment of the present invention in which functions may be executed out of order from that shown or discussed, including substantially concurrently or in reverse order, depending on the functionality involved, as would be understood by those reasonably skilled in the art of the present invention.

It should be emphasized that the above-described embodiments of the present invention, particularly, any "preferred" embodiments, are merely possible examples of implementations, merely set forth for a clear understanding of the principles of the invention. Many variations and modifications may be made to the above-described embodiment(s) of the invention without departing substantially from the spirit and principles of the invention. All such modifications and variations are intended to be included herein within the scope of this disclosure and the present invention and protected by the following claims.

The invention claimed is:

1. A device for grasping and supporting a live object, the device comprising:

a pair of counter rotating supporting structures configured to compel the live object in an x-translational direction at an x-translational speed, each supporting structure including an upper portion and a lower portion, and wherein the upper portion includes a plurality of apertures having a first configuration and the lower portion includes a plurality of apertures having a second configuration;

a compliant finger disposed within each of the plurality of apertures, the pair of counter rotating supporting structures are further configured to provide an opening for receiving the live object and wherein the compliant fingers are further configured to grasp and hold a body of the live object;

a speed control module for controlling the speed and timing of the rotation of the supporting structures;

a pallet assembly having a perch bar supporting structure, the perch bar supporting structure including perch bars;

a shackle assembly movably affixed to the pallet assembly, the shackle assembly comprising a pair of non-rigid grippers;

a trap bar assembly, the trap bar assembly rotatably affixed to the pallet assembly;

a shackle control mechanism affixed to the shackle assembly, the shackle control mechanism configured to lock and release the shackle assembly from the pallet assembly;

a trolley configured to move in an x-translational direction, the trolley affixed to the pallet assembly; and

said pallet assembly comprising a bottom panel, a first side panel hingedly connected to a side of said bottom panel, and a second side panel hingedly connected to a side of said bottom panel at a location opposite to the first side panel.

2. The device of claim **1**, wherein each compliant finger further comprises a structural rigidity between approximately 0.08 Nm^2 and approximately 0.35 Nm^2.

3. The device of claim **1**, wherein the lower portion of the supporting structure is further configured to include at least three compliant fingers each disposed in an individual aperture for supporting a body of the live object.

4. The device of claim **3**, wherein the upper portion of the supporting structure is further configured to include at least two compliant fingers for constraining the body of the live object from above.

5. The device of claim **4**, wherein the three compliant fingers each disposed in an aperture in the lower portion of the supporting structure further comprises a first finger of a first length, a second finger of a second length and a third finger of a third length.

6. The device of claim **5**, wherein the two complaint fingers each disposed in an aperture in the upper portion of the supporting structure further comprises a fourth finger of a fourth length and a fifth finger of a fifth length.

7. The device of claim **1**, wherein the compliant fingers disposed in the plurality of apertures in the upper portion of the supporting structure incline upward and the compliant fingers disposed in the plurality of apertures in the lower portion of the supporting structure incline downward.

8. The device of claim **1**, wherein the compliant fingers comprise a rubber material.

9. The device of claim **1**, wherein the speed control module is further configured to synchronize the rotation of the supporting structures with a conveyor transporting the live object.

10. The device of claim **1**, wherein the speed control module is further configured to vary the x-translational speed of the live object while constraining the body in the compliant fingers.

11. The device of claim **10**, further comprising a conveyor for transporting the live object towards the pair of counter rotating supporting structures, the conveyor further comprises a pallet assembly having a perch bar movably affixed to the conveyor, and wherein the perch bar is configured to receive the live object.

12. The device of claim **11**, further comprising a shackle movably affixed to the perch bar, the shackle having a pair of grippers for gripping extended legs of the live object, and wherein when the perch bar declines under the shackle, the set of compliant fingers of the pair of counter rotating supporting structures constrains the live object therein.

13. The device of claim **12**, wherein the speed control module controls the timing of the rotation of the supporting structures such that the rotation of the supporting structures is synchronized with the movement of the pallet assembly.

14. The device of claim **12**, wherein the speed control module controls the timing of the rotation of the supporting structures in relation to the speed of the conveyor such that the rotation of the supporting structures moves the live object from the compliant fingers of the pair of counter rotating supporting structures at a specified rate.

15. The device of claim **1**, wherein the pair of counter rotating supporting structures are further configured to rotate at a same speed.

16. The device of claim **1**, wherein the pallet assembly is configured to include rollers for traversing on a conveyor, the pallet assembly further being configured to travel along a separate track of the conveyor from a track of the conveyor utilized by the trolley.

17. The device of claim **16**, wherein the conveyor further comprises a drop cam, configured to define a transition in a z-direction, wherein the z-direction comprises a normal vector relative to a conveyor surface.

18. The device of claim **17**, wherein the trolley is configured to move along the drop cam in a z-translational direction while continuing to travel in the x-translational direction.

19. The device of claim **17**, wherein the shackle control mechanism further comprises a shackle stopper and a shackle releaser, and wherein the shackle stopper and shackle releaser provide for a move or stop control in both an x and z-direction.

20. The device of claim **19**, wherein the shackle assembly further comprises a shackle and an x-translational guide, the x-translational guide configured to provide for forward and backward movement of the shackle in the x-translation direction relative to the pallet assembly, and movement of the shackle in the z-direction to stay above the pallet assembly when the trolley of the pallet assembly moves along the drop cam.

21. The device of claim **1**, further comprising a back panel affixed to a rear portion of the pallet assembly.

22. The device of claim **1**, wherein the trap bar assembly comprises a magnetic lock, a roller and a cam, and the trap bar assembly is configured to rotate along an axis that is fixed with respect to the pallet assembly.

23. The device of claim **1**, further comprising a pair of counter rotating supporting structures for receiving a live object deposited onto the pallet assembly, each supporting structure includes an upper portion and a lower portion each having a plurality of apertures disposed therein, and wherein the pair of counter rotating supporting structures are further configured to provide an opening for receiving the live object, and compliant fingers disposed within the apertures of each supporting structure, the compliant fingers are further configured to support and constrain a body of the live object.

24. The device of claim **23**, further comprising a speed control module for controlling the speed and timing of the rotation of the supporting structures in relation to movement of the conveyor.

25. The device of claim **1**, wherein the perch bars are configured to have a z-direction compliance.

26. The device of claim **1**, wherein the grippers are configured to have a y-direction compliance.

27. The device of claim **1**, wherein the shackle control mechanism further comprises a shackle stopper and a shackle releaser, and wherein the shackle stopper and shackle releaser provide for a move or stop control in both an x and z-direction.

28. The device of claim **16**, wherein the conveyor further comprises an inverter portion that follows an inversion path for inverting the isolated live object shackled in the shackle assembly.

29. The device of claim **16**, further comprising a first speed control module configured to control the speed of the conveyor.

30. The device of claim **29**, further comprising a second speed control module configured to control the speed and timing of the rotation of a plurality of supporting structures in relation to the speed of the conveyor.

31. The device of claim **1**, further comprising a locking mechanism configured to maintain a position of the pair of supporting structures.

32. The device of claim **31**, wherein the locking mechanism is further configured to release the body of the live object corresponding to a specific x-translational position.

33. A system comprising:

a pallet assembly having a perch bar supporting structure, the perch bar supporting structure including perch bars;

a shackle assembly movably affixed to the pallet assembly, the shackle assembly comprising a pair of compliant grippers;

a trap bar assembly, the trap bar assembly rotatably affixed to the pallet assembly;

a shackle control mechanism affixed to the shackle assembly, the shackle control mechanism configured to lock and release the shackle assembly from the pallet assembly;

a trolley, affixed to the pallet assembly;

wherein the pallet assembly is configured to include rollers for traversing on a conveyor, the pallet assembly further being configured to travel along a separate track of the conveyor from a track of the conveyor utilized by the trolley;

wherein the conveyor further comprises a drop cam;

wherein the shackle control mechanism further comprises a shackle stopper and a shackle releaser, and wherein the shackle stopper and shackle releaser provide for a move or stop control in both an x and z-direction; and

wherein the shackle assembly further comprises an x-motion guide configured to mount a trap-bar cam profile, magnetic lock and linear bearings that guide the shackle assembly in an x-direction, and z-motion guide rods on which the pair of compliant grippers and a shackle motion control rod are affixed.

34. An automated feet gripping system, comprising:

a pallet assembly for locking and releasing an isolated live object, the pallet assembly including a perch bar for receiving the isolated live object;

a conveyor for transporting the pallet assembly, the conveyor further configured to include a drop cam for lowering the pallet assembly;

a pair of rotating hands having fingers for fully supporting the isolated live object while the pallet assembly is lowered;

a shackle assembly movably affixed to the pallet assembly, the shackle assembly further configured to receive feet of the isolated live object from perch bars when the pallet assembly is lowered and to shackle the feet of the isolated live object in the shackle assembly;

a first speed control module for controlling the speed of a conveyor;

a second speed control module for controlling the speed and timing of the rotation of the pair of rotating hands in relation to speed of the conveyor;

a pair of counter rotating supporting structures configured to compel the live object in an x-translational direction at an x-translational speed, each supporting structure including an upper portion and a lower portion, and wherein the upper portion includes a plurality of apertures having a first configuration and the lower portion includes a plurality of apertures having a second configuration;

a compliant finger disposed within each of the plurality of apertures, the pair of counter rotating supporting structures are further configured to provide an opening for receiving the live object and wherein the compliant fingers are further configured to grasp and hold a body of the live object:

a speed control module for controlling the speed and timing of the rotation of the supporting structures; and

said pallet assembly comprising a bottom panel, a first side panel hingedly connected to a side of said bottom panel, and a second side panel hingedly connected to a side of said bottom panel at a location opposite to the first side panel.

35. The system of claim **34**, wherein the conveyor further comprises an inverter portion that follows an inversion path for inverting the isolated live object shackled in the shackle assembly.

36. The system of claim **35**, wherein the first speed control module and the second speed control module add claim to speed profile.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

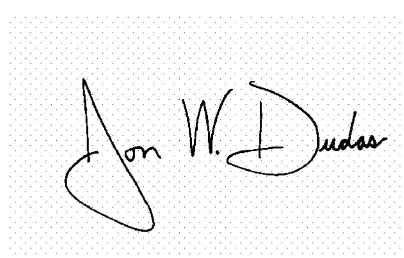
PATENT NO. : 7,134,956 B2
APPLICATION NO. : 10/618523
DATED : November 14, 2006
INVENTOR(S) : Lee

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 24, Lines 47-49, delete Claim 36.

Signed and Sealed this

Twelfth Day of June, 2007



JON W. DUDAS
Director of the United States Patent and Trademark Office